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AIR QUALITY

NORTHWESTERN ONTARIO

Annual Report, 1986

Ontario
Ministry of the Environment

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Regional Director
Northwestern Region

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NORTHWESTERN REGION
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SUMMARY

This report presents results of the Ministry's air quality assessment program in northwestern Ontario for 1986. It includes data from 11 communities where long-term monitoring is conducted, plus summaries of special studies in the Thunder Bay area.

ATIKOKAN

A report was released on pre-operational sampling around Ontario Hydro's power plant at Atikokan. During 1986, the first full year of operation for the plant, no exceedences were recorded of air quality objectives for sulphur dioxide, ozone, or nitrogen dioxide.

Suspended particulate matter, monitored at the Atikokan Weather Station, continued to be recorded at satisfactory levels.

BALMERTOWN

Arsenic persisted at elevated concentrations in vegetation on company property near two gold mines, but was near normal in the adjoining townsite. All vegetable samples from residential gardens met guidelines for arsenic and mercury.

In 1986, there were 79 hourly sulphur dioxide readings above the maximum acceptable limit, compared with 114 such occurrences in 1985. Growing season exceedences of the sulphur dioxide objective also declined from 61 in 1985 to 28 in 1986. A small area of vegetation injured by sulphur dioxide was restricted to company property. To avoid vegetation damage in the townsite, Campbell Red Lake Mines Limited operates a sulphur dioxide abatement program during the growing season.

DRYDEN

Monitoring continued near a secondary treatment system (lagoon) for kraft pulp mill effluent. An odour measurement survey around the lagoon began late in the year, but yielded

inconclusive results. Off-property fallout of foam did not pose a significant nuisance problem in 1986.

Odour levels, caused by total reduced sulphur (TRS) from a kraft pulp mill, declined in the town centre in 1986, continuing the trend started in 1982. There were only 12 exceedences of the TRS guideline during the year, compared with hundreds of annual exceedences before the mill was modernized in the early 1980's.

FORT FRANCES

There was no new vegetation injury recorded off company property near the Fort Frances kraft pulp mill in 1986.

Levels of dustfall and suspended particulate matter were about the same as preceding years. Emissions of wood fines and saltcake from mill operations sometimes contributed significantly to dustfall readings above the provincial objective.

At the monitoring point nearest the pulp mill, TRS concentrations exceeded the provincial guideline during 300 hours in 1986.

The company and the Ministry closely monitor mill operations to minimize upset conditions which could lead to excessive odour and particulate emissions. These emissions, plus other issues, will be addressed in a new Control Order currently being developed.

KENORA

Dustfall near a sulphite pulp mill sometimes exceeded Ontario objectives. Particulate matter emissions from the mill must meet Ministry regulations by June, 1988.

There has been no evidence of a sulphur dioxide problem near the Kenora mill for several years.

LONGLAC

Some dustfall readings were above the desirable level, but none was excessively high. Particulate monitoring from 1984 to

1986 indicates that conical wood waste burners at two local wood-using plants have not caused a significant fallout problem in the townsite.

MARATHON

Average levels of airborne sulphur compounds have shown little change during recent years. However, concentrations of TRS exceeded the provincial guideline on 115 occasions at the Ministry's monitoring station in the townsite, compared with 52 exceedences in 1985. Recently implemented and other planned changes at the local pulp mill should result in decreased odour emissions.

Mercury levels appear to have stabilized in soil near a former chlor-alkali plant at the pulp mill. No further mercury sampling surveys are planned.

RED ROCK

Following modest increases in 1984 and 1985, dustfall in 1986 declined to 1983 levels. Average dustfall met Ministry objectives in the townsite. The absence of significant particulate fallout in Red Rock was also demonstrated from snow sampling and moss exposure surveys. Under a new Control Order, an emission inventory report to assess the need and feasibility of further controls on particulate matter will be submitted by the company to the Ministry in 1987.

Average odour levels were about the same in 1985 and 1986; there were 87 exceedences of the TRS guideline in 1986. The current Control Order requires compliance with the TRS guideline by the end of 1988.

TERRACE BAY

Total reduced sulphur was above the Ontario guideline in Terrace Bay for 72 hours in 1986 because of emissions from the local kraft pulp mill. To achieve compliance with the TRS guideline by June 1989, as required in the current Control Order,

process improvements will be implemented at the mill to reduce odour emissions.

THUNDER BAY

Average dustfall in Thunder Bay in 1986 was within the acceptable range at all monitoring locations, and has been essentially unchanged for several years. Dustfall near a kraft pulp mill further declined from 1985 to 1986, reflecting a reduction in emissions from the mill's power boilers.

Average suspended particulate matter in the air was satisfactory during the year. Over 98 percent of the samples met the 24-hour Ontario air quality objective. Soiling index levels were also acceptable throughout the year.

Carbon monoxide, nitrogen dioxide, ozone and sulphur dioxide consistently met provincial criteria during 1986. Near a kraft pulp mill, total reduced sulphur exceeded the guideline during 4 hours in the year.

RÉSUMÉ

Le présent rapport présente les résultats pour l'année 1986 du programme d'évaluation de la qualité de l'air mené par le ministère de l'Environnement dans le Nord-Ouest de l'Ontario. Il comprend les données provenant de onze localités faisant l'objet d'une surveillance à long terme et des résumés d'études spéciales effectuées dans la région de Thunder Bay.

ATIKOKAN

Un rapport a été publié sur le prélèvement d'échantillons près de la centrale d'Ontario Hydro à Atikokan avant son entrée en service. En 1986, soit la première année entière d'exploitation de la centrale, les limites pour l'anhydride sulfureux, l'ozone et le dioxyde d'azote dans l'air n'ont pas été dépassées.

Les concentrations de particules en suspension mesurées à la station météorologique d'Atikokan étaient toujours jugées acceptables.

BALMERTOWN

Les concentrations d'arsenic étaient encore élevées dans la végétation située sur les terrains de la compagnie près de deux mines d'or, mais elles étaient presque normales dans la ville avoisinante. Les concentrations de mercure et d'arsenic de tous les échantillons de végétation prélevés dans les jardins résidentiels étaient inférieures aux limites.

En 1986, 79 mesures d'anhydride sulfureux effectuées toutes les heures dépassaient la limite maximale, comparativement à 114 en 1985. Pendant la saison de végétation, cette limite n'a été dépassée qu'à 28 reprises en 1986 comparativement à 61 en 1985. On a remarqué qu'une petite zone de végétation avait été endommagée par l'anhydride sulfureux et qu'elle se trouvait sur le terrain de la compagnie. Afin d'éviter pareils dommages dans la ville, Campbell Red Lake Mines Limited a mis en place un programme de réduction des émanations d'anhydride sulfureux pendant la saison de végétation.

DRYDEN

La surveillance de l'effluent provenant d'un bassin de traitement secondaire de l'usine de papier kraft s'est poursuivie. On a commencé à analyser les odeurs près du bassin vers la fin de l'année mais les résultats n'ont pas été concluants. Les retombées de mousse au-delà des limites de l'usine n'ont pas posé de problème majeur en 1986.

Les odeurs, causées par le soufre réduit total (SRT) provenant de l'usine de papier kraft, ont diminué au centre-ville en 1986; la tendance à la baisse qui a débuté en 1982 se produit donc. La limite de SRT n'a été dépassée qu'à douze reprises au cours de l'année, comparativement à des centaines de fois annuellement avant la modernisation de l'usine au début des années 1980.

FORT FRANCES

En 1986, la végétation hors de l'usine de papier kraft de Fort Frances n'a pas été endommagée, par rapport aux années antérieures.

Les concentrations de particules en suspension et les retombées de poussière étaient semblables à celles des années précédentes. Les rejets de poussière de bois et de sulfate de l'usine ont parfois contribué dans une large mesure au dépassement de la limite provinciale pour les retombées de poussière.

Au point de surveillance situé le plus près de l'usine, les concentrations de SRT ont été supérieures à la limite provinciale pendant 300 heures en 1986.

La compagnie et le ministère surveillent étroitement l'usine afin de réduire au minimum les conditions pouvant causer l'émanation excessive de mauvaises odeurs et de particules. Ces émissions, ainsi que d'autres aspects, feront l'objet d'un nouvel arrêté d'intervention qui est en préparation.

KENORA

Les retombées de poussière près de l'usine de papier, qui utilise le sulfite au cours du traitement, étaient parfois supérieures aux limites ontariennes. Les rejets de particules provenant de l'usine doivent être conformes aux règlements du ministère d'ici juin 1988.

Depuis plusieurs années, l'anhydride sulfureux ne semble causer aucun problème près de l'usine de Kenora.

LONGLAC

Dans certains cas, les retombées de poussière dépassaient les limites acceptables mais n'ont jamais atteint des niveaux excessifs. La surveillance des particules entre 1984 et 1986 indique que les brûleurs coniques des déchets de bois de deux usines locales n'ont pas entraîné de retombées majeures sur la ville.

MARATHON

Les concentrations moyennes de composés de soufre dans l'air ont peu changé au cours des dernières années. Toutefois, à la station de surveillance du Ministère dans la ville de Marathon, les concentrations de SRT ont dépassé la limite provinciale à 115 reprises, comparativement à 52 en 1985. Les mesures récemment adoptées par l'usine de papier, de même que celles qui le seront bientôt, devraient réduire les odeurs émanant de l'usine.

Les concentrations de mercure dans le sol près d'une ancienne installation de production de chlore et d'alcali à l'usine de papier semblent s'être stabilisées. On ne prévoit pas d'autres analyses de mercure.

RED ROCK

Après de légères hausses en 1984 et 1985, les retombées de poussière sont revenues aux niveaux de 1983. Les niveaux moyens pour la ville étaient conformes aux limites fixées par le Ministère. Les analyses d'échantillons de neige et de mousse végétale ont confirmé l'absence de retombées importantes de particules à Red Rock. En vertu d'un nouvel arrêté d'intervention, la compagnie présentera au Ministère en 1987 un inventaire de ses émanations qui permettra d'évaluer la nécessité et la faisabilité de mesures additionnelles de réduction des particules.

En moyenne, les odeurs étaient sensiblement les mêmes en 1985 et 1986. La limite de SRT a été dépassée à 87 reprises en 1986. En vertu du présent arrêté d'intervention, les émissions de SRT doivent être inférieurs à cette limite d'ici la fin de 1988.

TERRACE BAY

Les concentrations de SRT étaient supérieures à la limite ontarienne à Terrace Bay pendant 72 heures en 1986, en raison des rejets de l'usine de papier kraft. Afin de ne plus dépasser cette limite à partir de juin 1989, conformément à l'arrêté d'intervention en vigueur, on apportera aux méthodes de traitement employées à l'usine des améliorations visant à réduire les odeurs.

THUNDER BAY

À chacun des points de surveillance à Thunder Bay, les retombées de poussière étaient en moyenne dans les limites acceptables en 1986 et elles varient peu depuis plusieurs années. Les retombées près d'une usine de papier kraft ont continué de baisser de 1985 à 1986 en raison de la réduction des émanations provenant des chaudières de l'usine.

Les concentrations moyennes de particules en suspension dans l'air étaient acceptables pendant l'année. Plus de 98 pour 100 des échantillons étaient conformes à la limite ontarienne de 24 heures pour la qualité de l'air. L'indice de souillure était également à un niveau acceptable pendant toute l'année.

Les concentrations de monoxyde de carbone, de dioxyde d'azote, d'ozone et d'anhydride sulfureux ont toujours été conformes aux critères provinciaux en 1986. Les concentrations de SRT près d'une usine de papier kraft ont dépassé la limite provinciale pendant quatre heures au cours de l'année.

INTRODUCTION

PURPOSE OF MONITORING PROGRAM

The Ontario Ministry of the Environment conducts an air quality assessment program throughout the province. This program measures outdoor concentrations of pollutants that may adversely affect human health, animal life, vegetation, and the use and enjoyment of property. These surveys record compliance with air quality objectives, and determine long-term air quality trends. The monitoring program identifies pollution sources and assesses the results of pollution control measures.

In northwestern Ontario, air quality surveys first began in 1963 to measure airborne dust in the City of Thunder Bay. By 1986, the Ministry's monitoring program had expanded to include 10 pollutants monitored by more than 100 instruments in 11 communities. Ontario Hydro also has air quality networks in Thunder Bay and Atikokan.

Data from air quality and meteorological instruments are supplemented by vegetation, soil and snow sampling studies, and by predictions of pollutant levels with mathematical models.

Monitoring in the region is mostly conducted in urban areas and near industrial sources of air pollution (eg. mining, pulp and paper). Therefore, air quality problems described in this report are not typical of the region, where air quality is generally excellent.

Acid rain is a major environmental issue in eastern North America and in parts of Europe. Ontario, through its Acidic Precipitation in Ontario Study, is assessing the effects of acid fallout and is developing possible answers to this problem. The Ministry's Northwestern Region participates in this program through precipitation sampling surveys at 12 sites and through research on the aquatic and terrestrial effects of acid rain. The findings of these studies are reported elsewhere.

A major new development in the air quality program in northwestern Ontario is the installation of a telemetry system to

greatly increase the speed with which data are received. This system was installed in late 1986. It permits the Ministry to obtain immediate readings from any continuous monitor in the region. When initial technical problems with the new system have been resolved, a daily Air Quality Index (AQI) will be published for Thunder Bay. The AQI will be based on readings for six pollutants: carbon monoxide, ozone, nitrogen dioxide, particulate matter (soiling index), sulphur dioxide, and total reduced sulphur. As resources permit, the publication of an AQI may be extended to other communities in the region.

POLLUTANTS AND THEIR MEASUREMENT

Under this heading, only those contaminants routinely monitored in northwestern Ontario are considered. Hydrocarbons are not presently measured, nor are exotic organic compounds. If the need arises, many of the more unusual pollutants can be monitored with mobile equipment from the Ministry's Air Resources Branch, Toronto.

Particulate Matter

There are many man-made and natural sources of airborne particulate matter. Typical man-made sources in northwestern Ontario are forest product industries and mining operations. Wind-blown particles from stored materials and roadways are examples of secondary sources. Particulate matter may also be emitted from forest fires, volcanoes, and dust storms. Depending on particle size and chemical makeup, particulate matter may be harmful to health and vegetation, may adversely affect visibility, and may cause local nuisance problems. In Ontario, particulate matter is measured as dustfall, total suspended particulate matter (TSP), and soiling index.

Dustfall is particulate matter that settles out from the air by gravity. Open-top containers (dustfall jars) are exposed for 30-day periods and the collected matter is weighed.[1] The monthly air quality objective (maximum acceptable limit) for dustfall is

7 g/m²/30 d (grams per square metre during 30 days). The annual objective is 4.6 g/m²/30 d. Dustfall estimates the fallout of particulate matter from local sources, including dust from nearby construction or from vehicular traffic. It is rarely considered to be a health-related pollutant.

Suspended particulate matter comprises particles of small size which remain entrained in the air for long periods. This material may come from local or distant sources. It is measured with a high-volume sampler for a 24-hour period every sixth day.[2] The difference in the weight of a fibreglass filter before and after exposure in the sampling device determines the quantity of particulate matter collected. The air quality objective is 120 µg/m³ (micrograms per cubic metre of air) averaged over 24 hours, or 60 µg/m³, annual geometric mean.

Soiling index is a measure of the soiling or darkening properties of very small airborne particles and is expressed as coefficient of haze (COH). It is related to the concentration of respirable particulate matter. A measured volume of air passes through a paper tape which moves through an automated sampling unit to produce a reading every hour. The reduction of light transmitted through the tape is expressed as coefficient of haze (COH) per 1,000 linear feet of air sampled. The Ontario objective is 1.0 COH, 24-hour average, and 0.5 COH, annual average.

Gaseous Pollutants

Carbon Monoxide (CO)

Carbon monoxide is a colourless, odourless gas. Its primary source (about 80%) is motor vehicles. A secondary source is fossil fuel combustion. As the number of vehicles in northwestern Ontario is small, relative to other parts of the province, carbon monoxide is not believed to be a problem pollutant in this region. Elevated concentrations of carbon monoxide cause well-known health effects. The maximum acceptable

level in Ontario is 30 ppm (parts of carbon monoxide per million parts of air), 1-hour average, and 13 ppm, 8-hour average. This pollutant is measured with a continuous analyzer[3] at one location in Thunder Bay.

Fluoride

In northwestern Ontario, a tile plant near Thunder Bay is the only known significant industrial source of airborne fluoride. Fluoride may injure vegetation or impair the health of livestock which has consumed fluoride-contaminated forage. Fluoride in air is monitored with passive samplers (lime candles) which estimate mean monthly fluoride levels. The fluoride formed by the reaction of hydrogen fluoride with lime-impregnated filter paper is determined by laboratory analysis and is expressed as µg F/100 cm^2/30 days (micrograms of fluoride per 100 square centimetres of filter paper during a 30-day exposure period). The Ontario guideline is 40 µg F/100 cm^2/30 days during the growing season (May to September), and 80 µg F/100 cm^2/30 days during the rest of the year.

Nitrogen Oxides (NO_x)

Nitric oxide (NO) and nitrogen dioxide (NO_2) are together termed nitrogen oxides (NO_x). Both NO and NO_2 may be emitted from natural and man-made sources. High-temperature fuel combustion, which occurs in vehicle engines and thermal power plants, is the main man-made emission source. At concentrations measured in ambient air, NO has no known adverse effects. NO may, however, oxidize to NO_2 which, in turn, may adversely affect health and visibility. NO_2 also reacts with hydrocarbons in sunlight to form ozone. It may also combine with water to form nitric acid, a component of acid rain. Nitrogen oxides are monitored with continuous analyzers.[4] The air quality objectives for NO_2 are 0.2 ppm, 1-hour average, and 0.1 ppm, daily average.

Ozone (O_3)

Ozone occurs naturally and beneficially in the upper atmosphere. Near the ground, it is a product of reactions between nitrogen oxides and hydrocarbons. If it is present at high concentrations, it may adversely affect health and damage vegetation. Since ozone-forming compounds are not emitted in large amounts in northwestern Ontario, elevated ozone readings, if present, would suggest long-range transport from outside the region. Ozone is measured with continuous analysers,[5] and the current air quality objective is 0.08 ppm, averaged over one hour.

Sulphur Dioxide (SO_2)

Sulphur dioxide is one of the world's major atmospheric pollutants and has many well-known adverse effects on human health, vegetation and property. It is also one of the main contributors to acid rain. In northwestern Ontario, the principal SO_2 sources are small compared to those in some other parts of the province. The main regional emitters of SO_2 are, in approximate descending order of importance, Ontario Hydro generation stations (Thunder Bay and Atikokan), sulphite pulp mills, gold ore roasting, and industrial boilers. SO_2 may be measured with passive samplers (sulphation plates) to provide a semi-quantitative estimate of the presence of sulphur-containing gases. Results are expressed as monthly sulphation rates, in mg SO_3/100 cm^2/d (milligrams of sulphur trioxide per 100 square centimetres of treated filter paper per day). Sulphur dioxide is also monitored with continuous analyzers.[6] There are three air quality objectives for this pollutant: 0.25 ppm, hourly average; 0.10 ppm, 24-hour average; and 0.02 ppm, annual average.

Total Reduced Sulphur (TRS)

Total reduced sulphur comprises a group of sulphur-containing gases found in emissions from kraft pulp

mills, which are the sole significant TRS source in the region. At very low concentrations, TRS results in offensive odours. Higher levels may cause temporary respiratory irritation or may injure vegetation. In Ontario, a guideline of 27 ppb (parts of TRS, expressed as hydrogen sulphide, per billion parts of air), averaged over one hour, is used as an air quality objective near kraft pulp mills. TRS may be measured with sulphation plates, for semi-quantitative results, or with continuous analysers.[7]

Miscellaneous

The occurrence and effects of some of the foregoing pollutants, plus others, are assessed by vegetation injury and by measuring contaminant levels in vegetation, soil and snow. Standard Ministry procedures[8,9,10] are followed in collecting and analysing these types of samples. Arsenic, chloride, fluoride,[11] sulphur and heavy metals are typical pollutants examined this way. Their levels in a study area are compared with normal background values at sites unaffected by pollution. Contaminant guidelines developed by the Ministry for vegetation, soil and snow are used in this report. The guidelines are based on "normal" elemental concentrations in vegetation across the province. Exceedence of the guidelines would suggest that contamination may be present, but would not necessarily imply adverse effects.

Dustfall, sulphation, and suspended particulate matter determinations, as well as most analyses for vegetation, soil and snow, are carried out at the Ministry's Thunder Bay laboratory. The Ministry's Toronto laboratory analyses metals, nitrate, and sulphate in suspended particulate matter, and sulphur and halides (chloride, fluoride) in vegetation and soil. The Toronto laboratory also analyses unusual contaminants (e.g.: organic compounds such as PCBs or pesticides).

The Ministry's Air Resources Branch processes the strip charts from continuous analyzers, and produces computer printouts of all air quality and meteorological data for the region. When

technical problems with the new telemetry system have been resolved, the Ministry's Thunder Bay office will have immediate access to all air quality and meteorological data across northwestern Ontario.

RESULTS AND DISCUSSION

ATIKOKAN

Ontario Hydro Generating Station

In 1981, the Ministry and Ontario Hydro began a monitoring program around a lignite-fired generating station under construction near Atikokan. In the air quality part of this program, Ontario Hydro operates the air quality monitoring network and the Ministry collects precipitation, vegetation, soil, and snow samples at several sites (Figure 1). By late 1985, when the 200-megawatt plant went into service, at least three years of background data had been collected.

Consultants for Ontario Hydro submitted quarterly and annual air quality reports for the pre-operational monitoring. The Ministry prepared annual reports on terrestrial studies. A summary report for the pre-operational terrestrial and atmospheric deposition studies was released.[12] These studies confirmed the presence of historical arsenic and iron contamination in vegetation and soil near the power plant. This contamination was caused by emissions from nearby iron ore pelletizing plants which operated from the mid-1970's to about 1980. Mercury in Atikokan soils was also found at levels higher than expected. The source of the mercury has not been determined. Precipitation chemistry was normal.

The Ministry and Ontario Hydro continued their monitoring programs during 1986, the first full operational year for the power plant. No exceedences of Ontario's air quality objectives for sulphur dioxide, ozone, or nitrogen dioxide were recorded in

1986 by Ontario Hydro's Atikokan monitoring network. To ensure compliance with environmental regulations, assessment studies will be carried out, as required, in future years.

Particulate Matter

In 1986, at the Ministry's long-term monitoring site in the Town of Atikokan, all 55 samples of TSP complied with the 24-hour air quality objective of 120 $\mu g/m^3$. The annual geometric mean of 21 $\mu g/m^3$ was well below the maximum acceptable limit of 60 $\mu g/m^3$, and was similar to values reported for preceding years.

BALMERTOWN

The Ministry has conducted air quality surveys near two gold mines in Balmertown since 1971. For many years, Campbell Red Lake Mines Limited, and the Dickenson-Sullivan Joint Venture, Arthur W. White Mine (formerly Dickenson Mines Limited), emitted significant amounts of airborne arsenic trioxide and sulphur dioxide from ore roaster stacks. In the mid-1970's, both mines reduced arsenic emissions by more than 95%. In early 1980, Dickenson changed its ore processing methods and shut down its roaster.

Arsenic

In 1986, arsenic concentrations in leaves of trembling aspen trees at 17 sites (Figure 2) near the mines remained elevated on company property but were near normal levels in the townsite. The elevated arsenic on company property is ascribed to localized fugitive emissions from arsenic-containing wastes or from concentrates. Table 1 compares arsenic readings for 15 years at selected sites on and off company property. Table 2 presents 14 years of data from planted roadside trees in the townsite. Both tables show that current arsenic levels in vegetation are much lower than those in the early 1970's. The increase in arsenic in roadside trees in 1986 compared to 1985 (Table 2),

suggests that fugitive emissions at the mine sites may have to be better controlled.

Arsenic in garden vegetables was below the former limit (approximately 10 µg/g, dry weight) specified by the Health Protection Branch, Canada Department of Health and Welfare (Table 3). Because arsenic in garden soil remains high, Balmertown residents are advised to thoroughly wash vegetables from their gardens.

Mercury

Because mercury has been used in ore processing at the mines, the Ministry regularly examines mercury levels in the local environment. Mercury exceeded the Ministry's contaminant guideline in trembling aspen leaves at one site on company property near the Dickenson mine, but was normal in the townsite. All vegetable samples from residential gardens met the recommended international guideline for mercury (0.5 µg/g, dry weight). Campbell Red Lake discontinued the use of mercury in late 1982, but it is still used at Dickenson.

Sulphur Dioxide

Sulphur dioxide sometimes exceeds desirable levels in Balmertown. In 1986, the Ministry's Balmertown monitor recorded 79 hourly SO_2 readings and two 24-hour averages which exceeded acceptable levels. The maximum hourly average was 0.79 ppm, about three times the Ontario objective. The annual average (0.008 ppm) was satisfactory. In 1986, sulphur dioxide injury to vegetation was found only in a small area of 1.7 hectares on company property.

During the growing season (May to September), SO_2 was above the acceptable hourly limit 28 times, compared with 61 occasions in 1985. An 11-year summary of SO_2 data is presented in Table 4. Nearly half the 1986 growing season exceedences occurred in September, when potential damage to vegetation would be minimal.

To avoid significant vegetation damage, Campbell Red Lake Mines has an SO_2 abatement program, under which its ore roaster is shut down when the wind carries roaster-stack emissions over the townsite.

DRYDEN

For several years, the Ministry has monitored air quality near a bleached kraft pulp mill and adjacent chlor-alkali plant in Dryden. The earliest surveys showed that mercury, particulate matter and offensive odours around the mill were often well above desirable levels. Abatement action and process changes in the 1970's successfully controlled the discharge of mercury and particulate matter. Mill modernization in the early 1980's reduced emissions of odour-causing TRS. In 1986, the Ministry continued to monitor odour levels in the town centre. It also began a sulphation rate measurement study around the mill's secondary treatment system (lagoon).

Lagoon

A secondary treatment system (lagoon) was constructed in late 1983 to process effluent from the Dryden mill. Initially, wind-blown foam and odours from the lagoon caused a nuisance to area residents. The foam problem has now largely been resolved, although additional controls will be undertaken.

Special Ministry studies in 1985 found no evidence of potential health effects from airborne substances near the lagoon.[13] In August 1986, a sulphation measurement network (Figure 3) was established around the lagoon and in Dryden to obtain data on odour levels and to help determine the best site for a continuous odour monitor (Figure 3). The sulphation readings from August to December 1986 were inconclusive; only during the warmer months of August and September were values recorded above the detection limit. Moss exposure studies and vegetation sampling during the summer showed that the lagoon was still a source of airborne sodium. Sodium levels, however, were

generally lower than those found in 1985. At off-property sampling sites, sodium exceeded the Ministry guideline in only one moss sample and one aspen foliage sample. Chloride and mercury levels in moss and in aspen leaves were consistently low.

In late 1987, the Ministry plans to install an analyzer to continuously monitor odour levels near the lagoon.

Kraft Mill

Odour Levels

Offensive odours caused by reduced sulphur compounds are monitored with a continuous TRS analyzer in central Dryden (station 61027, Figure 3). As Table 5 shows, air quality at this location continued the trend of improvement shown in recent years. The number of hours of TRS above the provincial guideline was the lowest yet recorded.

FORT FRANCES

During its first few years of operation, emissions from a bleached kraft pulp mill in Fort Frances resulted in particulate fallout and odour problems in a nearby residential area. In the late 1970's, some emission reductions were achieved. In 1980, a Control Order was issued for further pollution controls. The mill also created a "buffer zone" through purchase of adjacent residential land.

Air quality studies in Fort Frances have been conducted regularly since 1972 near the Canadian mill, and periodically since 1974 around a similar plant owned by the parent corporation on the U.S. side of the border (Figure 4).

Vegetation Effects

In 1986, there was trace to moderate air pollution injury on foliage of a few Manitoba maple trees in the buffer zone near the Fort Frances mill. There was no new vegetation injury outside

this zone. Saltcake deposition was noted on the leaves of some trees nearest the mill in the buffer zone. Foliar analysis of sodium, used as a tracer of saltcake emitted from the mill, showed that the impact area was in, or very close to, company-owned property (Table 6). Differences in foliar sodium levels between years may not be very significant; rainfall differences from year to year may have a greater effect on foliar sodium than changes in emissions from the mill. The decline in foliar chloride levels during the past few years (Table 6) suggests that emissions of chlorine and chlorine compounds from the mill may also have decreased during the same period.

There was no visible off-property damage to vegetation around the secondary effluent treatment system on Eighth Street (Figure 5).

Particulate Matter

Dustfall results for 1986 are summarized in Table 7. The annual air quality objective for dustfall was met at only the two most distant sites from the mill (stations 62032 and 62037). On-property dustfall averaged about three times the objective. Dustfall outside mill property was about twice the objective. Wood fibres accounted for about 25 to 75% of total dustfall when high dustfall readings occurred at sites around the mill off company property (stations 62034, 62035, 62036 and 62050). Saltcake comprised about 20% of total dustfall at these locations. Road dust, fly ash, and insect parts were also sometimes present in significant amounts in dustfall, mainly during the summer. A comparison of average dustfall during recent years (Table 8) shows no significant trend from 1979 to 1986. Snow sampling, which is conducted annually, confirms the dustfall results.

In common with dustfall, total suspended particulate matter (TSP) showed no significant change in 1986 from earlier years. The annual average TSP at the monitoring site near the mill (station 62035) was 60 $\mu g/m^3$ and met the provincial objective.

Nine of the 54 daily readings exceeded the 24-hour objective. Highest readings occurred with southerly wind, when the monitor was downwind of the mill. The annual average TSP at the Fort Frances cemetery (station 62032) was 29 $\mu g/m^3$, which is normal for this location and well within the Ontario objective. There were no exceedences of the daily objective at this site.

Odour Levels

After improvement in the late 1970's and early 1980's sulphation rate averages in Fort Frances have shown little change during the past few years (Table 9). There were 300 exceedences of the TRS guideline in 1986 at the Ministry's monitoring site near the Fort Frances mill (Table 10). The increase in guideline exceedences at this site and at station 62032 is likely due, at least partly, to more sensitive monitoring equipment installed at mid-year. Odour measurement was terminated in March at station 62051. This station will be re-activated at a nearby location in 1987.

Compared with the late 1970's, odour levels in Fort Frances in 1986 were much lower. However, there are still many exceedences of the TRS guideline. Proposed abatement measures in a new Control Order should reduce the frequency of guideline exceedences.

A new TRS monitor is planned for the Eighth Street area to document odour levels near the mill's secondary treatment system (lagoon) for liquid effluent. Provisions in the new Control Order should result in less odour around the lagoon. A special air quality study near the lagoon, carried out by the Ministry in 1985, showed that off-property TRS exceeded the Ontario guideline.

KENORA

For many years, the Ministry has monitored air quality near a sulphite pulp mill in Kenora. Occasional upset conditions at

the mill have caused localized vegetation damage. Fallout of particulate matter emitted from the mill's power boiler stack has also sometimes been a nuisance to nearby residents.

Particulate Matter

As Table 11 shows, average dustfall in Kenora in 1986 was lower than that for all but one of the past six years. Dustfall frequently exceeded the monthly objective at station 61007. Levels at the other three sites in the network (Figure 6) were acceptable. Wood or bark char, woodfines, and biological debris were major components of dustfall when elevated readings occurred. A Control Order requires the mill to comply with Ministry regulations for particulate matter by June 30, 1988.

Sulphation Rates

Average sulphation rates in 1986 were slightly higher than in 1985 (Table 12), but this difference is not significant. As a result of a successful abatement program, there has been no evidence of a sulphur dioxide problem near the mill for several years.

LONGLAC

Particulate Matter

To obtain data on fallout of particulate matter around two conical wood-waste (teepee) burners in Longlac, a small air monitoring network was established in late 1983 (Figure 7). Suspended particulate matter was measured in 1984 and 1985. Dustfall was monitored from 1984 to the end of 1986.

Dustfall data for the past three years are summarized in Table 13. Several monthly readings were above the desirable level, but none was excessively high. Dustfall at three of the five sites met the annual objective in 1986. Average dustfall for the townsite was the same as that for 1985. Air quality data from 1984 to 1986 do not indicate a serious fallout problem in the townsite from the teepee burners. Dustfall measurements were

discontinued at the end of 1986. Air quality data for Longlac, together with snow sampling results, are discussed in detail in a separate report.[14]

MARATHON

Historically, airborne contaminants of concern at Marathon have included mercury, particulate matter, and sulphur compounds emitted from a bleached kraft pulp mill and adjacent chlor-alkali plant. Mercury emissions ceased when the chlor-alkali plant was closed in 1977. Fallout of particulate matter in the townsite was shown in several surveys to be negligible. However, a new wood procurement policy at the mill has resulted in the creation of large wood chip piles. Wind-blown wood fines from these piles are a potential nuisance to nearby residents. The Ministry currently maintains five air quality monitoring stations in Marathon (Figure 8) and one in Heron Bay. James River-Marathon Limited has dustfall jars at five locations near their wood chip piles.

Odour Levels

Table 14 shows that average sulphation levels in the townsite have been variable following the completion of major mill modernization and pollution control programs in 1978.

Average and maximum TRS levels increased in Marathon in 1986, according to Table 15, compared with the three preceding years. The number of guideline exceedences doubled over 1985. To alert the mill when community odour levels exceed the desirable limit, the company telemeters TRS readings directly from the Ministry's monitor to the mill. Recent changes in the mill's recausticizing area, plus other scheduled improvements should result in decreased odour emissions. Further odour controls, if TRS guideline exceedences continue, will be negotiated by Ministry and company officials. The mill will be carrying out another emission inventory in 1989. Any sources

identified by the inventory as not in compliance with existing regulations will require further abatement action.

Particulate Matter

The fallout of wood fines from wood-chip piles near the pulp mill has been studied by the company and by the Ministry. Dustfall measurements and snow analysis shows that the fallout problem is restricted to a small area close to the chip piles.[15] The company is investigating ways to reduce dust emissions from the chip piles so that fallout of wood fibres does not cause a nuisance to area residents.

Mercury in Soil

For several years, the Ministry has sampled surface soil near the James River mill. The chlor-alkali plant, now closed, used a mercury-cell process. Table 16 summarizes mercury levels in soil at 9 sites (Figure 9a) sampled from 1976 to 1986. The distribution pattern for mercury in 1986 is shown for surface soil in Figure 9b. The fact that surface soils contain more mercury than sub-surface soil is evidence of airborne contamination. Highest mercury levels occurred near the former chlor-alkali plant. There seems to be no decline in mercury with time; other studies have also found that mercury does not readily disappear from contaminated soil.[16] Since mercury in soil on company property near the mill appears to be stable, we plan no further sampling in the near future.

RED ROCK

The Ministry operates a small air quality monitoring network in the Town of Red Rock to measure dustfall and odour levels near a kraft pulp mill. The network comprises four dustfall jars at stations 63080 to 63083, and a continuous TRS analyser at station 63084 (Figure 10).

Particulate Matter

Table 17 summarizes dustfall in Red Rock for the period before (1980-82) and after (1983-1986) a new recovery furnace was installed at the local pulp mill. Both total dustfall and saltcake in dustfall declined sharply after the new recovery furnace started up in late 1982. This reduction in particulate fallout is also confirmed by data in a recent report[17] on a moss exposure study. A snow sampling survey in early 1986[18] showed that Ministry guidelines were substantially met in the townsite area. In 1986, total dustfall at all monitoring sites off mill property met the annual air quality objective. Most of the infrequent exceedences of the monthly objective occurred at the monitoring site (station 63080) on mill property. A Control Order served on the company in 1986 requires it to identify emissions sources of particulate matter by September, 1987. This emission inventory report will also assess the need and feasibility of further controls on discharges of particulate matter.

Odour Levels

The number of exceedences of the TRS guideline decreased from 117 in 1985 to 81 in 1986 (Table 18). For the period since the new recovery furnace was installed, community odour levels have fluctuated, but have been much better than the pre-1982 period. Under the current Control Order, consistent compliance with the TRS guideline is required by the end of 1988. To achieve compliance, the company will be improving its steam stripping and non-condensable gas (NCG) system. Emission monitoring for TRS or equivalent will also be carried out.

TERRACE BAY

Past surveys have shown that the kraft pulp mill in Terrace Bay does not contribute to fallout of particulate matter in the adjoining townsite. Therefore, the Ministry's monitoring

program is directed toward measurement of odour levels in the townsite and at three points where an effluent ditch from the mill crosses the TransCanada Highway (Figure 11).

Odour Levels

Average sulphation rates in 1986 were similar to results for preceding years (Table 19). TRS data (Table 20) showed that, during 1986, there were 72 hourly readings above the provincial guideline of 27 ppb at the Ministry's monitoring site (station 63090, Figure 10). The maximum hourly average was 155 ppb. The 1986 results were similar to those for 1985. TRS data from the Ministry's monitor are continously telemetered to the mill. Under a new Control Order, Kimberly-Clark will be putting process improvements in place to reduce odour emissions. The Control Order calls for compliance with the TRS guideline by June, 1989.

THUNDER BAY

The Ministry maintains a 10-station air quality monitoring network in Thunder Bay. The locations of these sites, plus those operated by Ontario Hydro, are shown in Figure 12. Thunder Bay's first "full" air monitoring station (63200) was placed in service on South James Street in late 1986. At this station, sulphur dioxide, ozone, carbon monoxide, nitrogen oxides, soiling index and total reduced sulphur are continuously recorded. Station 63200 replaced station 63040, nearby. Three of the Ministry's Thunder Bay monitoring stations (63005, 63022, 63200) are part of Environment Canada's NAPS (National Air Pollution Surveillance) network. In addition to its network of five sulphur dioxide monitors, Ontario Hydro has dustfall jars at several sites on and near its Mission Island property to measure dust from flyash disposal and coal storage areas around its power plant. The following discussion reviews data from the Thunder Bay monitoring network, and includes brief summaries of some special studies carried out in the Thunder Bay area in 1986.

Particulate Matter

Dustfall

Dust emitted from grain elevators was formerly a nuisance to Thunder Bay residents. Dustfall measurements near the elevators began in 1970, and the monitoring network has been revised periodically since then. The 1986 data for the 10 sites now in service are summarized in Table 21. During the year, average dustfall was below the maximum acceptable limit at all 10 sites. Road dust and biological material accounted for most of the dustfall in the only two readings above the monthly objective.

Table 22 shows that pollution controls installed in 1983 on power boilers at the Great Lakes Forest Products Limited pulp and paper mill have been successful. Dustfall near the mill during the past winter was more than 75 percent lower than levels recorded in the early 1980's.

Suspended Particulate Matter and Soiling Index

Total suspended particulate matter was generally very satisfactory throughout Thunder Bay in 1986 (Table 23). Over 98 percent of the total samples for all six monitoring sites were below the 24-hour maximum acceptable limit of 120 $\mu g/m^3$. The annual objective was met at all locations. Filters from the two city-centre stations (63005 and 63022) had acceptable concentrations of heavy metals, including lead. Levels of sulphate and nitrate, which are influenced by long-range transport, varied considerably.

At stations 63040 and 63200, soiling index met the daily and annual air quality objectives for this pollutant.

Gaseous Pollutants

Carbon Monoxide

For the two months of available data in 1986, carbon monoxide was well below the maximum acceptable limit at station 63200.

Nitrogen Dioxide

Like carbon monoxide, nitrogen dioxide was monitored for only two months at station 63200. All values met provincial air quality objectives.

Ozone

Ozone did not exceed the maximum acceptable limit (80 ppb, 1-hour average), during 1986 at the Ministry's monitoring sites (stations 63040 and 63200) in Thunder Bay. The highest hourly average was 56 ppb. Ozone, a long-range transport pollutant, is not currently considered to be a problem in northwestern Ontario.

Sulphur Dioxide

The principal industrial sources of sulphur dioxide in Thunder Bay are a 310-megawatt lignite-fired generating station and four pulp and paper mills. Collectively, these sources are relatively small, and total SO_2 emissions in Thunder Bay are less than 100 metric tons per day. The network of seven SO_2 monitors (five belonging to Ontario Hydro and two owned by the Ministry) showed full compliance for all SO_2 air quality objectives in 1986 (Table 24).

Total Reduced Sulphur

At the Ministry's Montreal Street monitoring site (station 63046), the TRS guideline (27 ppb) was exceeded during 4 hours in 1986 (Table 25). These exceedences occurred after our TRS monitor was modified for improved response to TRS. Therefore, the slight apparent decline in air quality was probably a function of better monitoring rather than an actual change in air quality.

Special Studies

Thunder Bay Terminals Limited

A report on 1986 air quality monitoring near Thunder Bay Terminals Limited[19] showed that this coal terminal continued to operate satisfactorily. There has been no increase in dust levels at off-property monitoring sites since coal shipments began in 1978.

Acid Rain Studies, Hawkeye Lake

Most of the field work has been completed for studies on the terrestrial effects of acid rain in northwestern Ontario. This program was largely carried out in a 95-hectare watershed near Hawkeye Lake, about 40 kilometres north-northwest of Thunder Bay. Environmental monitoring at this site included continuous measurement of sulphur dioxide, nitrogen oxides and ozone. In 1986, sulphur dioxide and nitrogen oxides monitoring concluded at the end of March, while ozone monitoring continued. Very low levels of SO_2 and NO_2 were recorded for the first three months of the year. Ozone slightly exceeded the acceptable limit of 80 ppb during 5 hours in May, with a maximum hourly reading of 83 ppb. The results of other investigations at Hawkeye Lake will be reported separately.

Great Lakes Ceramics Inc.

Tile was produced intermittently during 1986 at Great Lakes Ceramics Inc. in Rosslyn Village, about 15 km west of Thunder Bay. During the year, fluoride levels were monitored with lime candles at six sites near the plant. Only one of the 70 values for the year exceeded the maximum acceptable level. Detailed results of this monitoring program, plus data from vegetation sampling, will be presented in a report now in preparation.

ACKNOWLEDGEMENT

The assistance of staff of the Atmospheric Environment Service, Atikokan Weather Station, for operating a high volume sampler is gratefully acknowledged.

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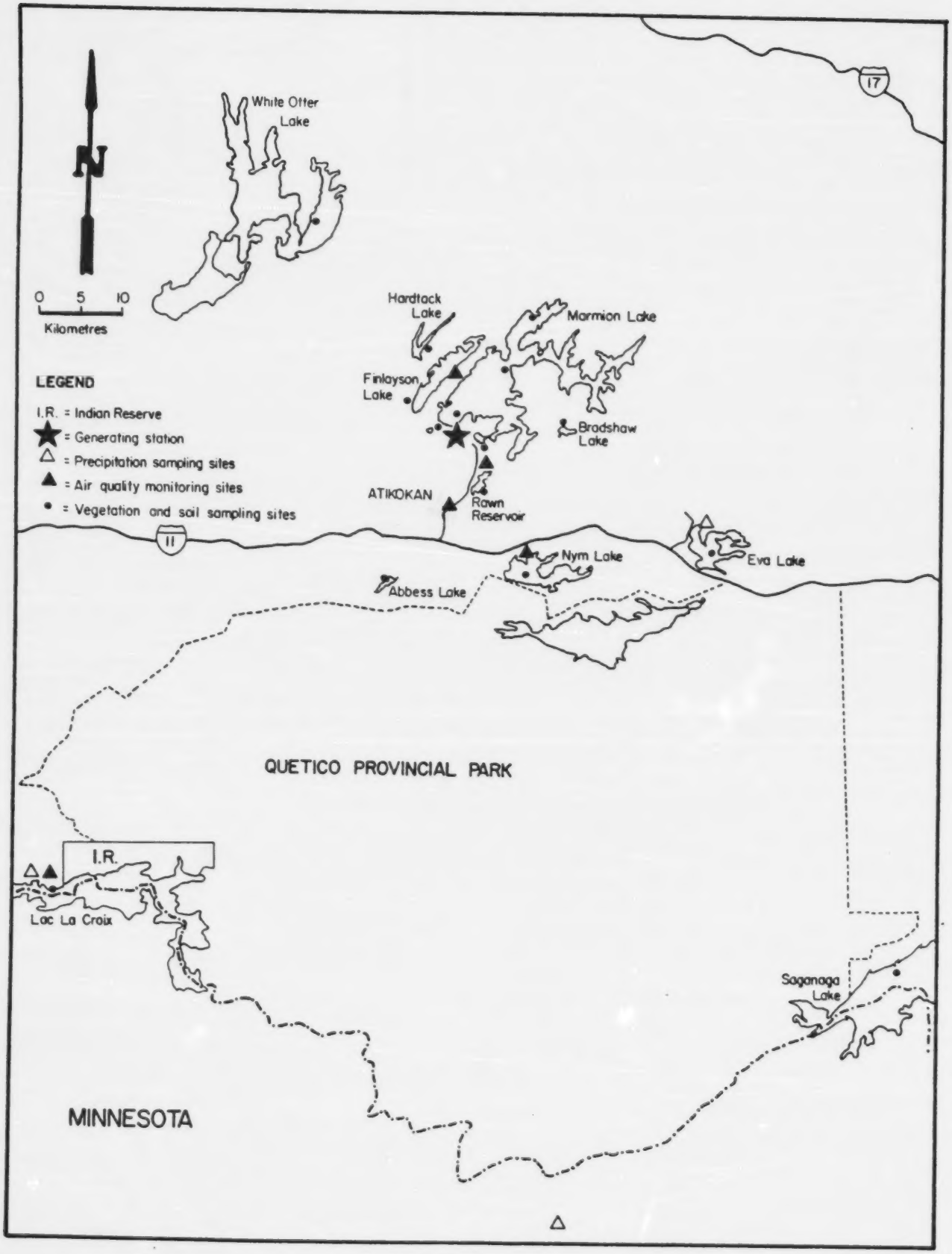

Figure 1. Air quality assessment sites, Ontario Hydro generating station, Atikokan.

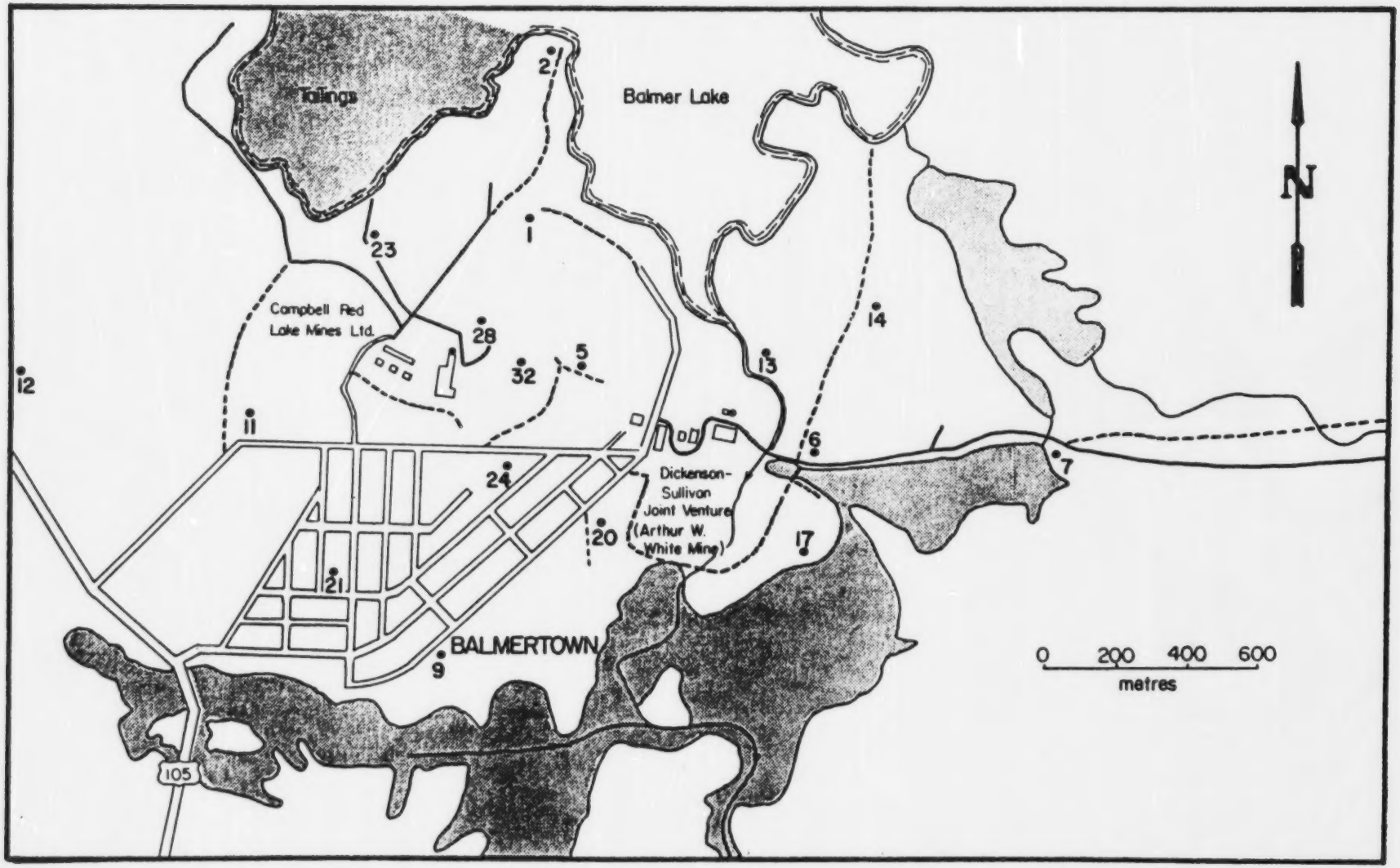

Figure 2. Trembling aspen sampling sites, Balmertown, 1986.

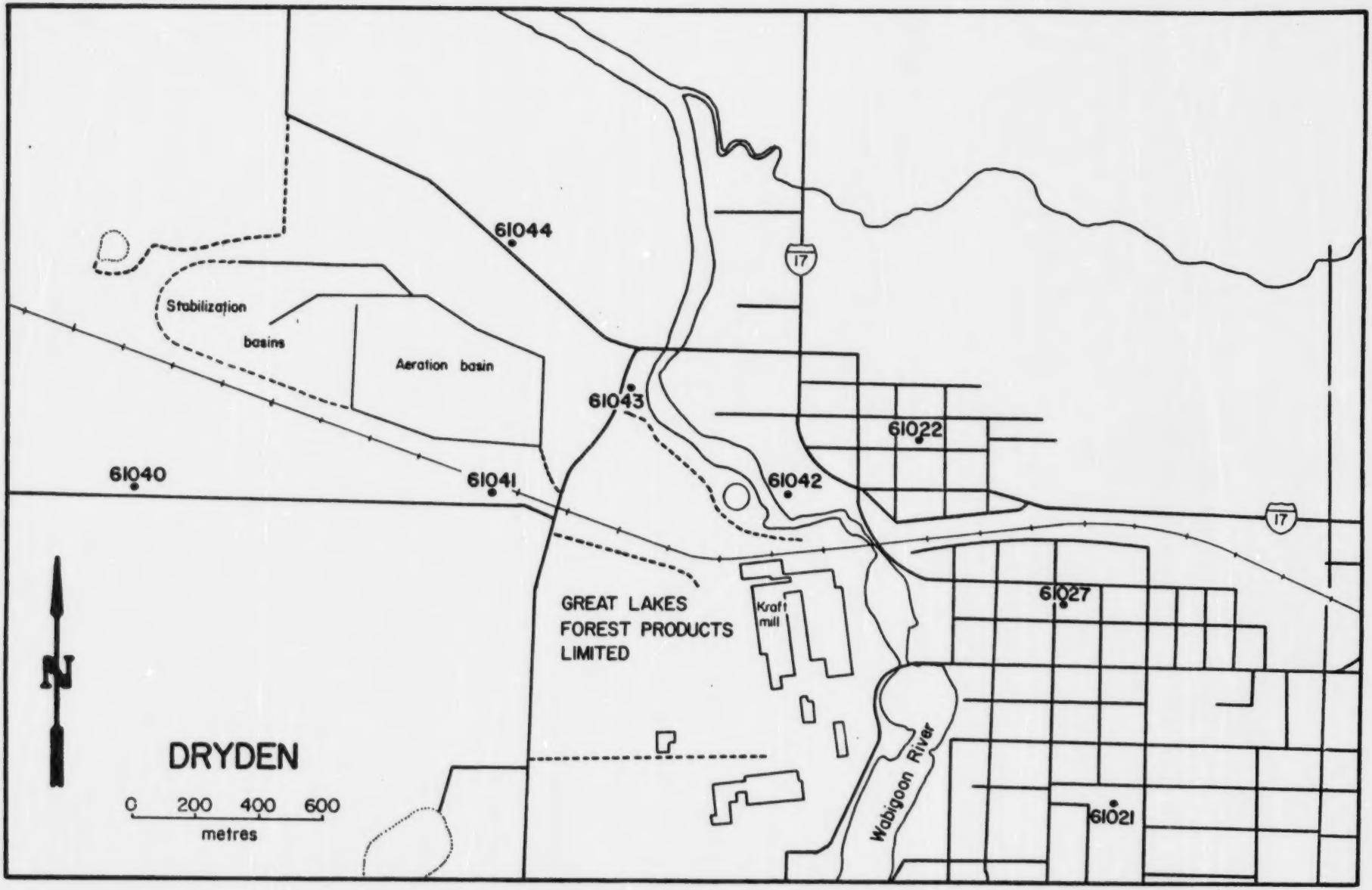

Figure 3. Air quality monitoring sites, Dryden, 1986 (Sulphation plates at all sites; continuous TRS monitor at 61027).

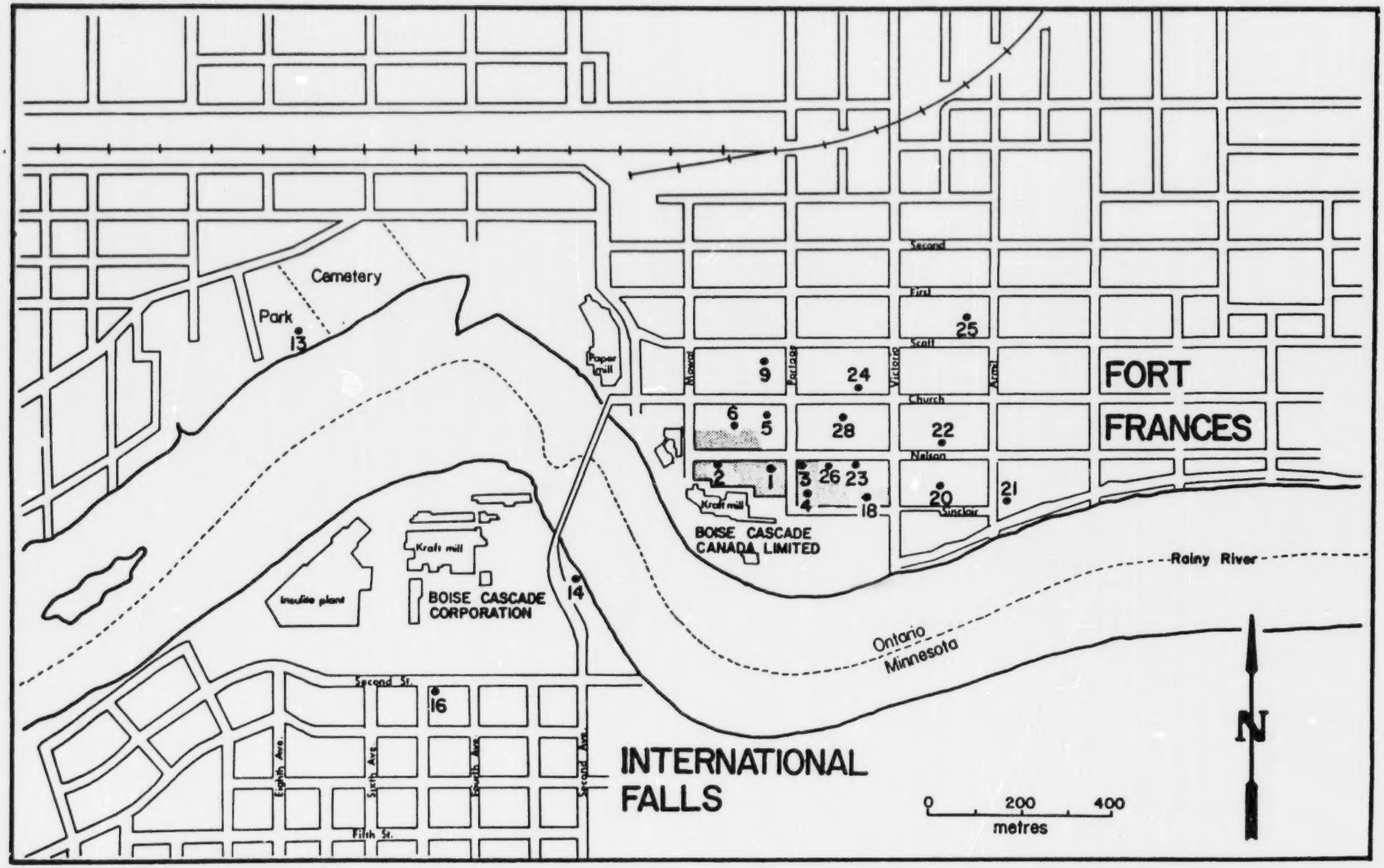

Figure 4. Manitoba maple sampling sites, Fort Frances, August, 1986.

Buffer zone

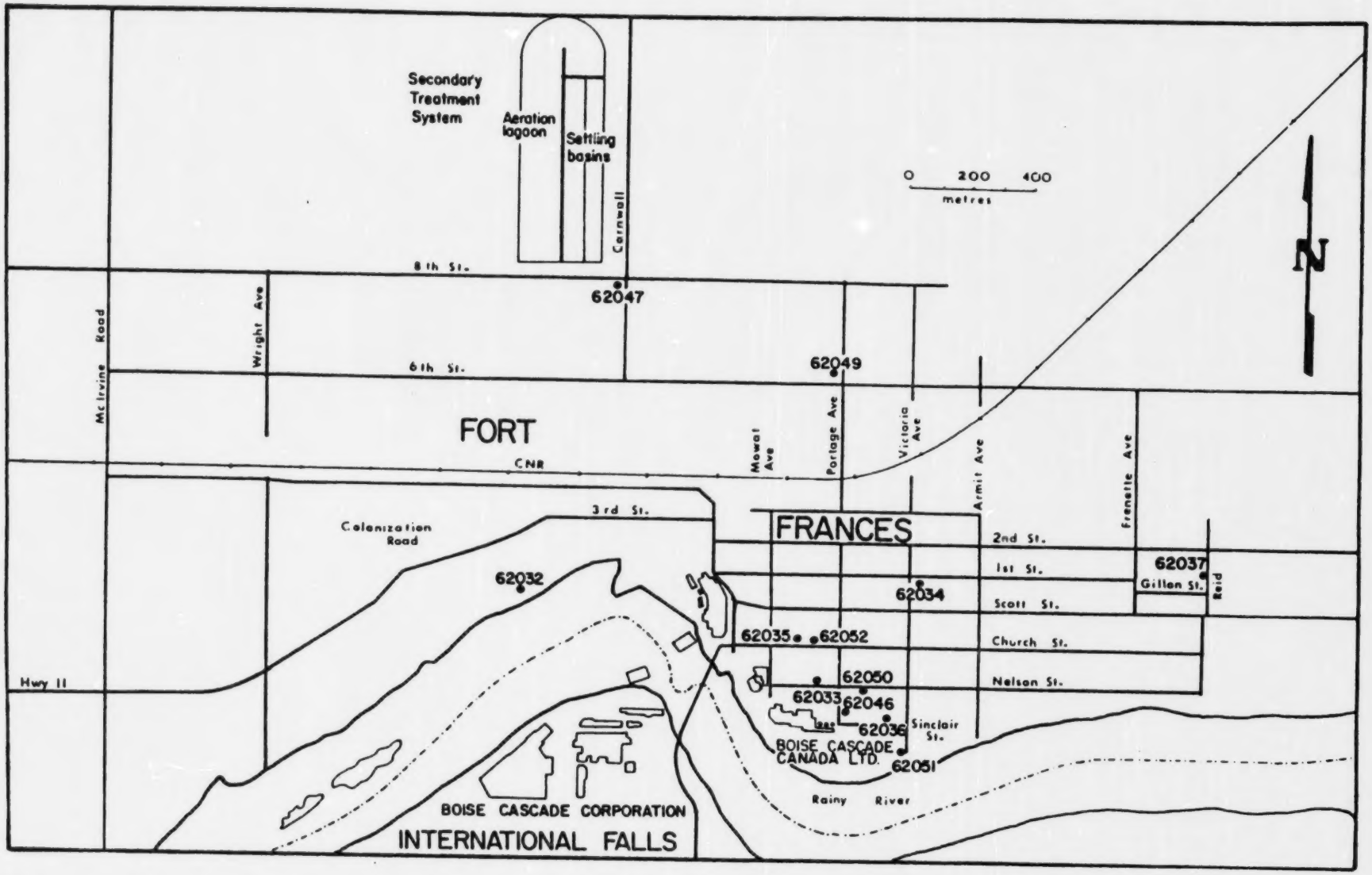

Figure 5. Air quality monitoring sites, Fort Frances, 1986.

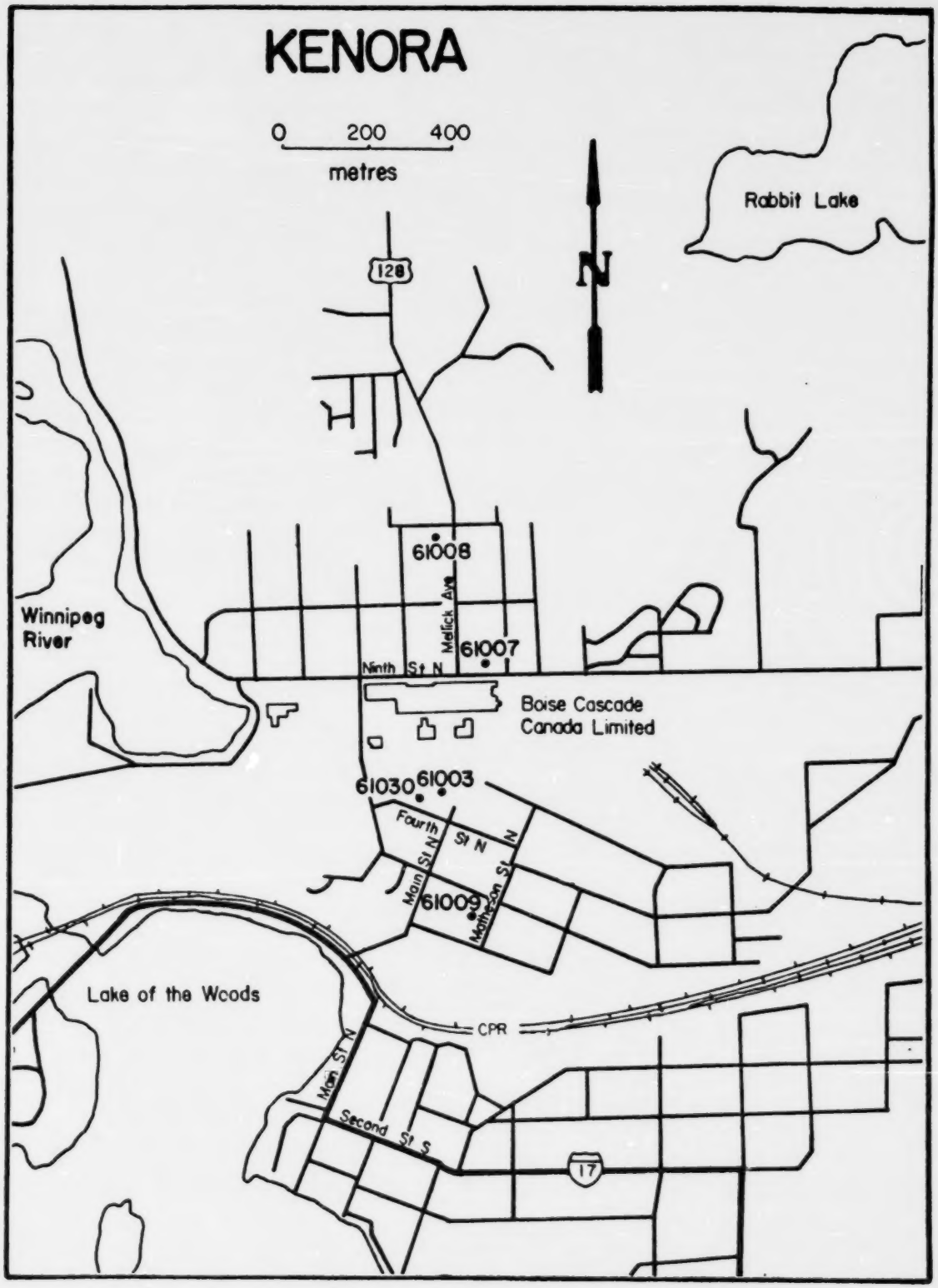

Figure 6. Air quality monitoring sites, Kenora, 1986.

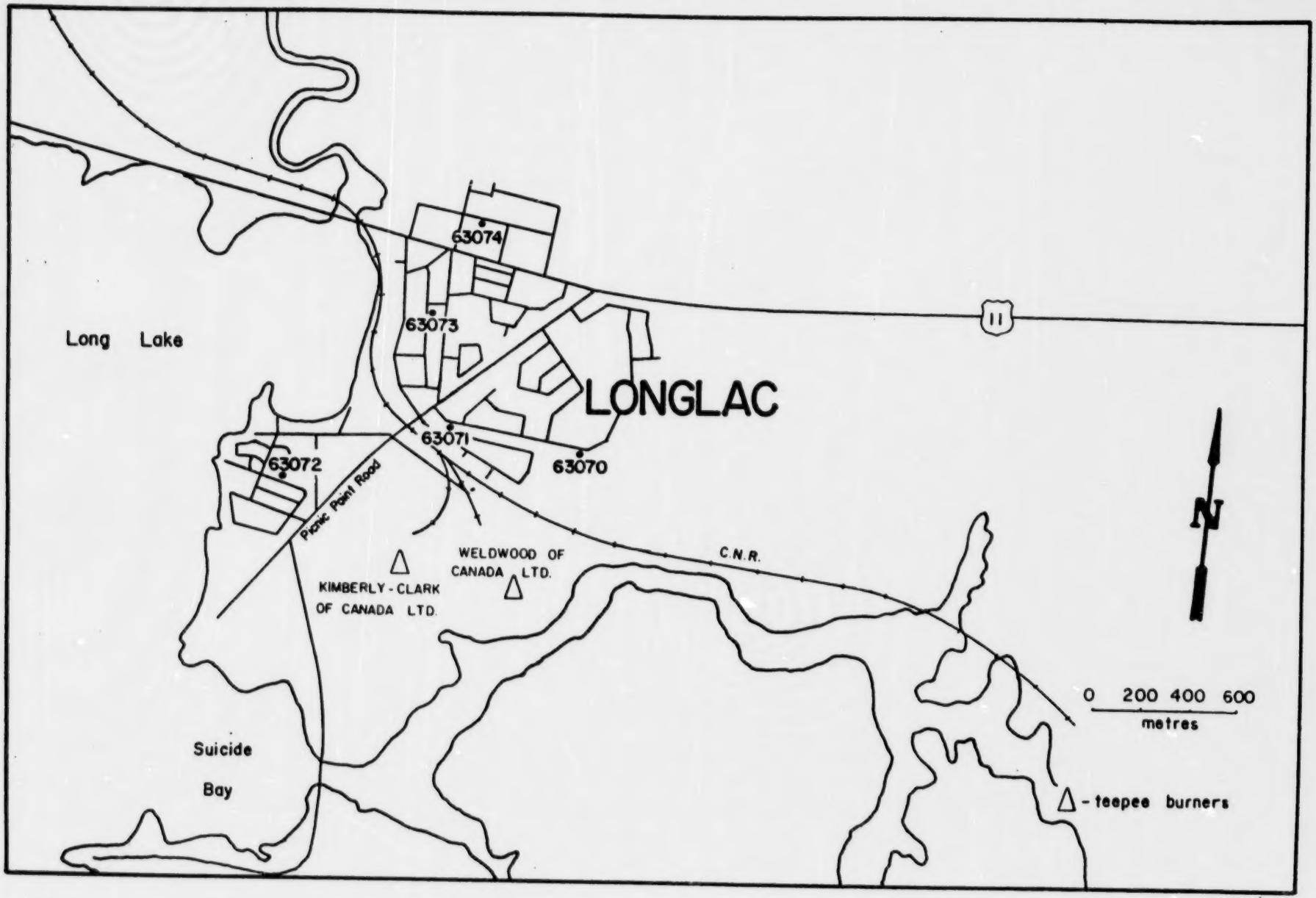

Figure 7. Air quality monitoring sites, Longlac, 1986.

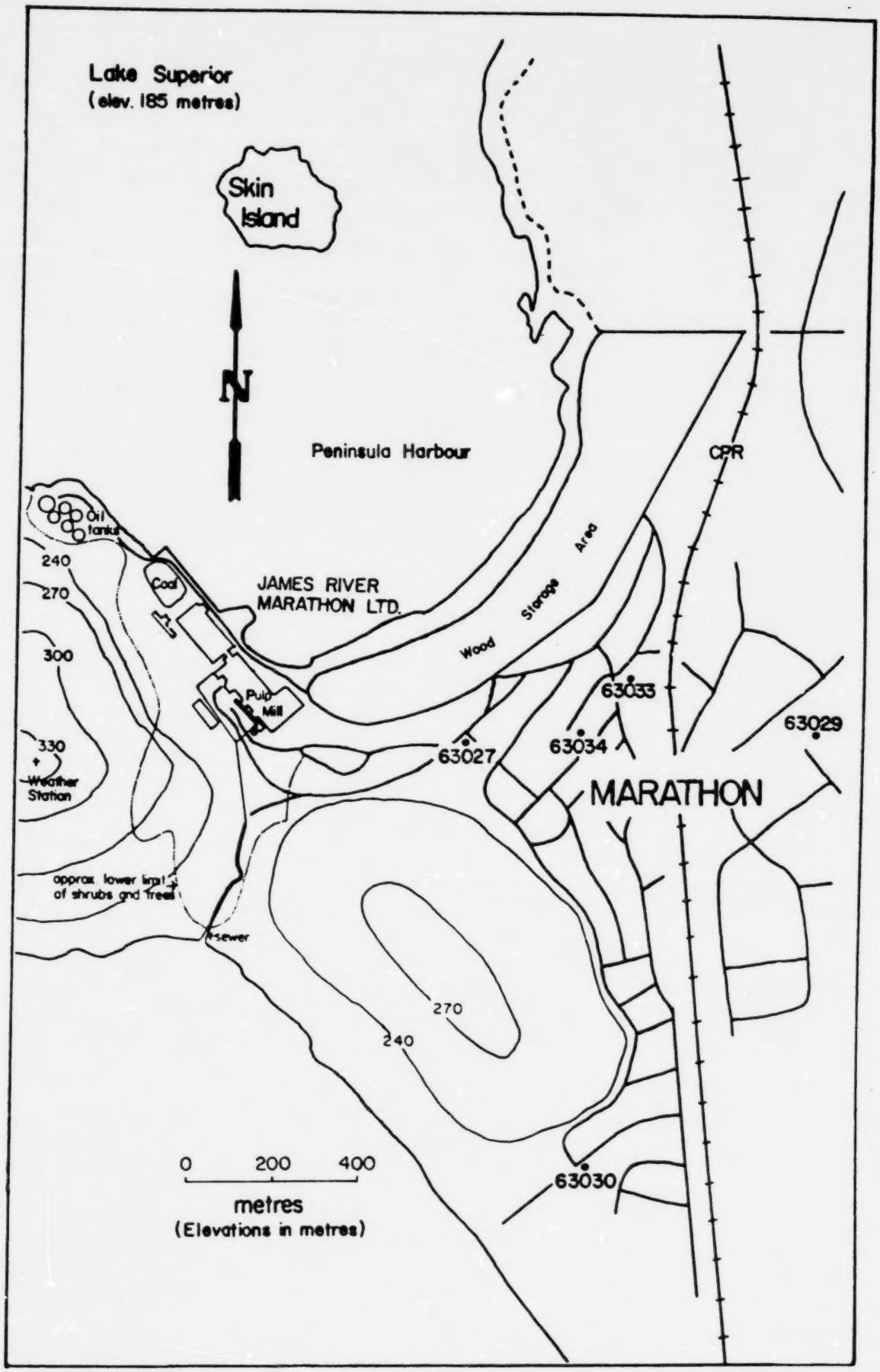

Figure 8 . Air quality monitoring sites, Marathon, 1986 (except station 63032, Heron Bay).

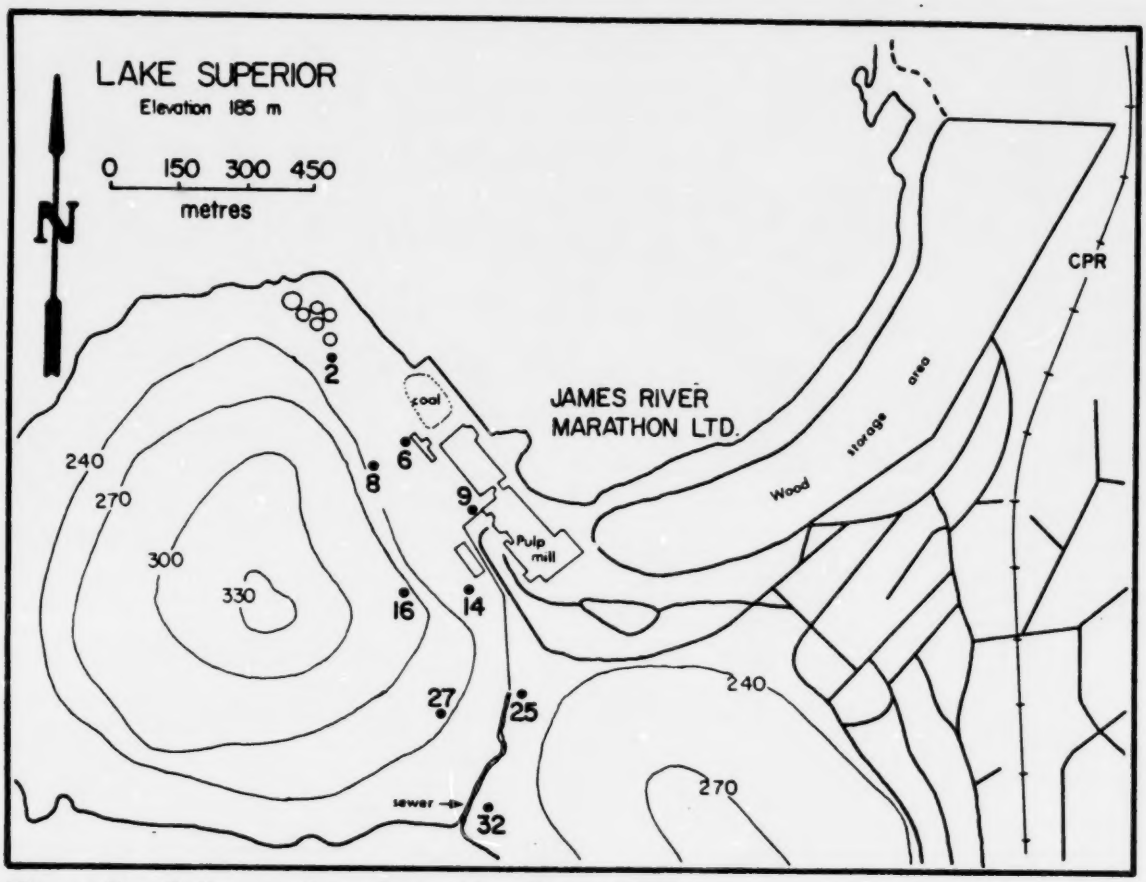

Figure 9a. Soil sampling sites, Marathon, 1986.

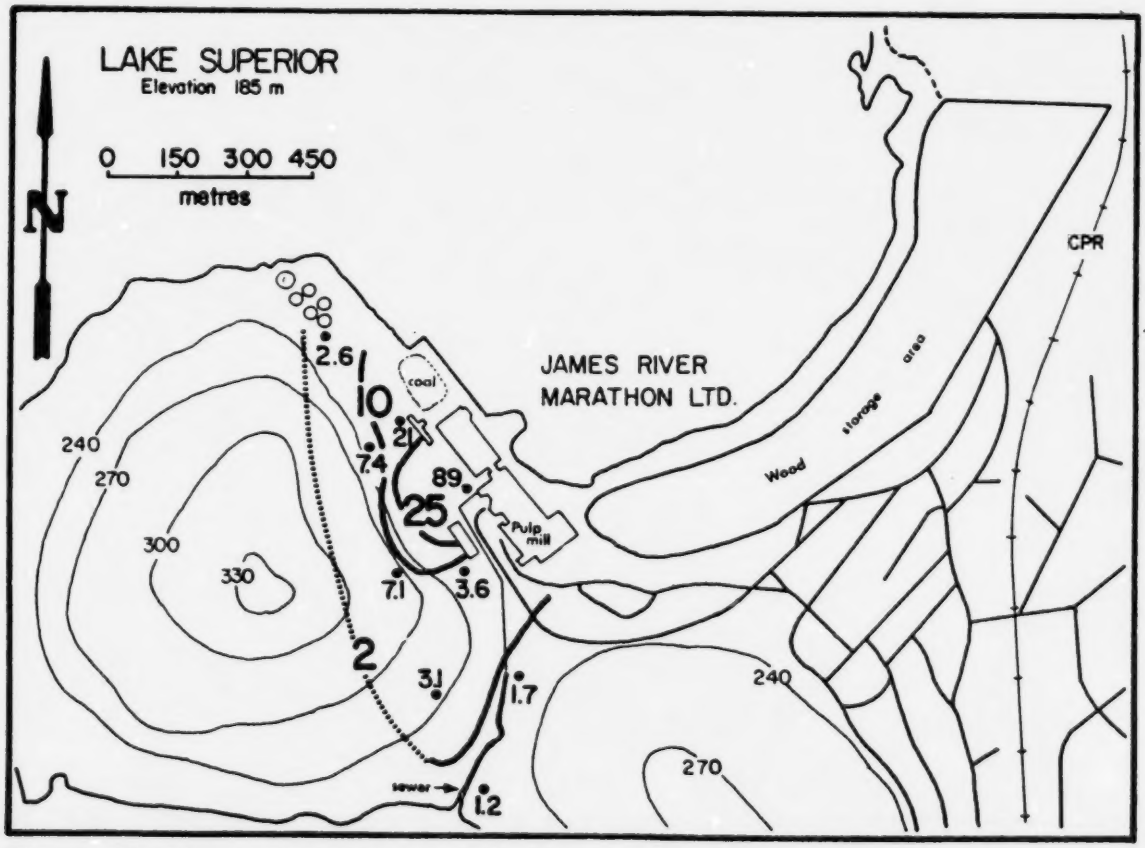

Figure 9b. Mercury in surface soil (0-5 cm), Marathon, 1986.

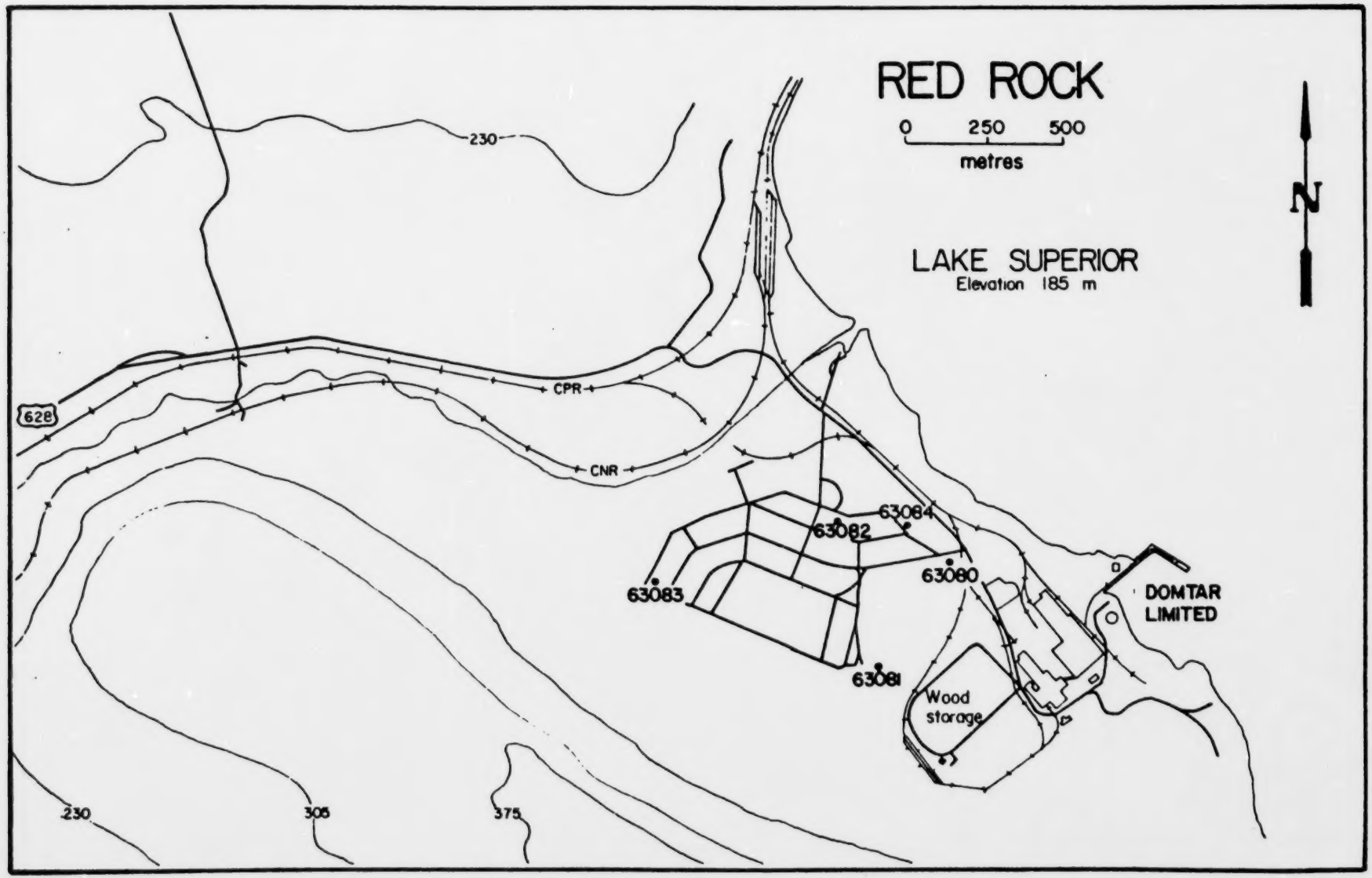

Figure 10. Air quality monitoring sites, Red Rock, 1986 (TRS only at 63084).

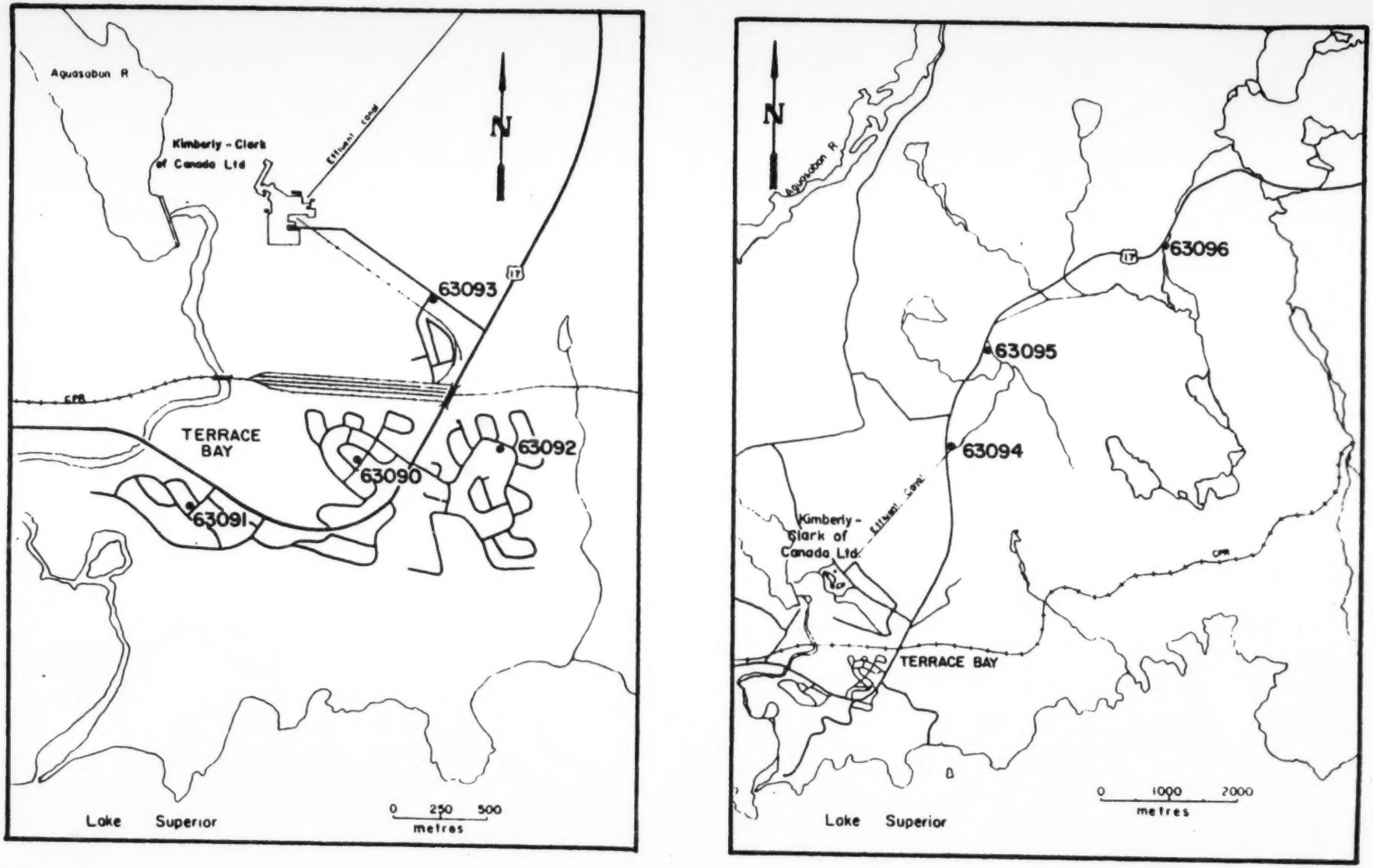

Figure 11. Air quality monitoring sites, Terrace Bay, 1986 (TRS at station 63090 only).

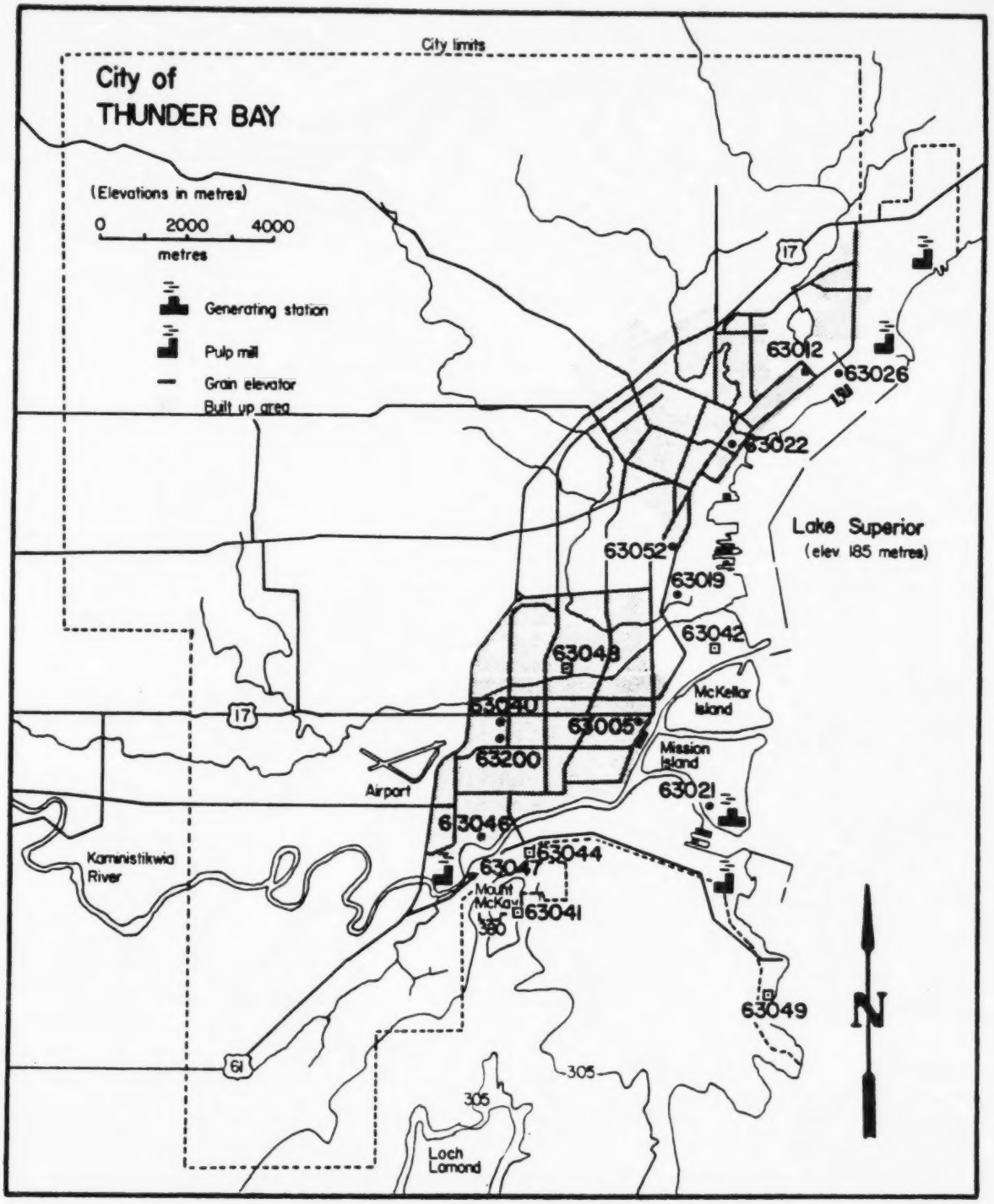

Figure 12. Air quality monitoring sites, Thunder Bay, 1986.

(⊡ Ontario Hydro sites)

TABLE 1. Arsenic content (µg/g, dry weight) of unwashed trembling aspen foliage near Balmertown, 1972 to 1986.

Site[a]	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
1			26[b]	31	10	5	4	3	6	5	9	5	4	4	6
2			22	26	6	12	9	3	6	4	12	6	6	6	8
5	160	550	29	33	18	12	9	22	28	6	60	19	11	16	23
6	78	400	200	260	50	8	33	11	55	63	36	38	14	13	28
7	21	81	43	29	5	4	20	4	4	2	5	5	3	4	6
9[c]	260	410	19	6	6	5	5	9	3	5	5	4	7	6	6
11	98	110	10	7	2	4	2	5	3	4	6	4	3	13	4
12	27	41	9	9	4	3	3	6	1	2	13	2	4	2	1
20[c]				6	5	7	6	13	5	3	25	3	14	5	2
21[c]				53	8	4	3	18	9	7	3	3	3	6	2
24[c]				26	13	17	5	11	17	9	25	5	6	11	5
Controls	<1	8	3	2	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1

[a]Shown in Figure 2.

[b]Values above contaminant guideline (2 µg/g) are underlined.

[c]Sites in townsite area.

TABLE 2. Average arsenic content (µg/g, dry weight)[a] of unwashed foliage from planted roadside Manitoba maple (Acer negundo) and white elm (Ulmus americana) trees, Balmertown, 1973 to 1986.

Year	Side of tree[b]	Dickenson & Mine Road	Balmertown public school	Fifth St. & Mine Road	Controls
1973	Facing	504[c]	734	352	19
	Away	323	432	202	25
1974	Facing	70	36	20	4
	Away	31	21	12	
1975	Facing	138	76	34	4
	Away	58	46	18	
1976	Facing	18	12	20	2
	Away	18	9	11	
1977	Facing	13	6	8	<1
	Away	16	5	8	
1978	Facing	5	5	5	<1
	Away	4	4	3	
1979	Facing	69		8	2
	Away	22		7	
1980	Facing	7	5	6	1
	Away	5	5	3	
1981	Facing	11	7	8	<1
	Away	12	7	5	
1982	Facing	14	8	10	<1
1983	Facing	18	7	-	<1
1984	Facing	8	4	3	<1
1985	Facing	12	6	5	<1
1986	Facing	26	4	12	<1

[a]Values for 1975 to 1979 are averages of triplicate samples. Those for other years represent single samples.

[b]Facing and away from gold mines.

[c]Values above contaminant guideline (2 µg/g) are underlined.

TABLE 3. Average arsenic levels[a] (µg/g, dry weight) in washed vegetables and surface soil (0-5 cm) from three Balmertown gardens, 1973-1986.

Sample	1973	1976	1978	1980	1982	1984	1986
	Balmertown						
Potato leaves[c]		15	6	17	13	11	6
Potato tubers		2	<1	2	<1	<1	<1
Beet leaves	180[d]	7	2	8	3	5	3
Beet roots	40	4	3	6	5	3	1
Lettuce leaves	140	12	9	36	8	20	6
Garden soil		60	120	160	100	82	96
Lawn soil		210	280	440	310	230	230
	Red Lake (control)						
Potato leaves[c]		2	1	2	2	1	2
Potato tubers		<1	<1	<1	<1	<1	<1
Beet leaves	3	<1	<1	2	<1	<1	<1
Beet roots	2	<1	<1	<1	<1	<1	<1
Lettuce leaves		<1	1	2	1	<1	<1
Garden soil		8	6	7	7	8	6
Lawn soil		9	11	11	13	10	8

[a] Values for 1976 and 1978 are averages of triplicate samples. Those for other years represent single samples.
[b] Two gardens in 1984 and 1986.
[c] Unwashed.
[d] Values above contaminant guidelines (2 µg/g for vegetation, 10 µg/g for soil) are underlined.

TABLE 4. Summary of sulphur dioxide data, Balmertown, 1976-1986.

Year	Days of data	Annual ave. (ppm)	Annual exceedences		Growing season exceedences	
			Hours	Days	Hours	Days
1976	195	0.015	76	6	63	6
1977	111	0.010	31	2	nil	nil
1978	335	0.014	133	9	73	6
1979	296	0.016	153	8	58	3
1980	247	0.011	76	6	24	1
1981	280	0.013	83	7	31	2
1982	273	0.013	104	7	66	4
1983	336	0.008	65	2	10	nil
1984	365	0.005	50	2	21	1
1985	341	0.010	114	3	61	2
1986	355	0.008	79	2	28	1

TABLE 5. Summary of concentrations (ppb) of total reduced sulphur, Dryden, 1977-1986.

Year	Days of data	Annual average	Maximum 1-hour average	Number of hours above guideline
1977	325	3.7	164	270
1978	282	6.7	479	400
1979	200	8.7	236	391
1980	275	6.1	436	476
1981	279	5.5	190	405
1982	312	2.1	139	153
1983	257	1.5	121	68
1984	327	1.1	187	28
1985	340	1.0	51	17
1986	352	1.0	77	12

TABLE 6. Average chloride and sodium concentrations in unwashed Manitoba maple foliage, Fort Frances-International Falls, 1980-1986.

Site[a]	Chloride (%, dry weight)			Sodium (µg/g, dry weight)		
	1980	1983	1986	1980	1983	1986
1b	1.20	0.40	0.36	1800[d]	1000	1700
2[b]	0.81	0.36	0.20	1400	1900	3600
3[b]	0.87	0.26	0.18	1200	210	620
4[b]	0.71	0.24	0.23	620	340	490
5	0.35	0.23	0.14	260	670	250
6	0.36	0.34	0.24	390	1800	1600
9	0.22	0.16	0.13	150	430	300
13	0.04	0.04	0.03	83	210	220
14[c]	0.08	0.08	0.12	53	470	310
16[c]	0.53	0.12	0.13	73	160	390
18	0.21	0.12	0.07	120	65	160
20	0.10	0.09	0.09	250	160	300
21	0.15	0.14	0.09	250	<25	330
22	0.13	0.13	0.08	240	63	620
23	0.26	0.10	0.12	280	98	420
24	0.42	0.22	0.09	210	83	240
25	0.17	0.10	0.10	410	96	260
26			0.17			710
28		0.14	0.12		110	250
Controls	0.10	0.06	0.04	100	<25	46

[a] See Figure 4 for site locations.

[b] Sites on company property.

[c] U.S. sites.

[d] Values above contaminant guideline (350 µg/g) for sodium in vegetation are underlined.

TABLE 7. Average annual dustfall (g/m²/30 d), Fort Frances, 1986.

Monitoring sites	Total dustfall	Insoluble dustfall	Saltcake in dustfall
62032	2.6	1.3	0.6
62033[a]	15.7[b]	7.3	4.8
62034	6.6	4.5	0.8
62035	9.7	5.3	2.1
62036	12.5	6.9	2.5
62037	3.1	1.3	0.7
62046[a]	14.1	8.4	2.6
62050	8.1	3.7	1.9
Averages	9.0	4.8	2.0
% of total dustfall		53	22

[a]Sites on company property.
[b]Values above the maximum acceptable limit (4.6 g/m²/30 d) are underlined.

TABLE 8. Average annual dustfall (g/m²/30 d) at six Fort Frances monitoring sites[a], 1979-1986. Percentages of total dustfall are shown in parentheses.

Parameter	1979	1982	1983	1984	1985	1986
Total dustfall	8.7	7.2	7.5	9.0	9.4	9.1
Insoluble dustfall	4.0(46)	4.0(56)	4.1(55)	5.2(58)	5.1(54)	5.0(55)
Saltcake in dustfall	2.1(24)	1.3(18)	1.2(16)	1.9(21)	1.2(13)	2.0(22)

[a]Stations 62032, 62033, 62034, 62036, 62037 and 62046.

TABLE 9. Average annual sulphation rates (mg SO_3/100 cm^2/d), Fort Frances, 1978-1986.

Station	Location	1978	1980	1982	1984	1986
62032	Cemetery	0.14	0.09	0.06	0.08	0.07
62033	Nelson/Portage	0.51	0.27	0.20	0.17	0.17
62034	First/Victoria	0.15	0.09	0.05	0.06	0.06
62035	Legion Building				0.10	0.10
62036	Sinclair/Victoria	0.19	0.09	0.06	0.06	0.06
62037	Reid/Gillon	0.11	0.09	<0.05	<0.05	<0.05
62046	Sinclair/Portage		0.12	0.10	0.13	0.10
62047	Eighth/Corwall			0.10	0.12	0.11
62049	Sixth/Portage			0.06	<0.05	0.06
	Averages				0.09	0.08

TABLE 10. Summary of total reduced sulphur concentrations (ppb) at stations 62030, 62052, 62032 and 62051, Fort Frances, 1976-1986.

Year	Days of data	Annual average	Maximum 1-hour average	Number of hours above guideline
	Station 62030/62052			
1976[a]	309	12.8	458	916
1977[a]	294	15.4	480	969
1978[a]	304	16.1	540	1035
1979[a]	344	10.2	353	911
1980[a]	352	9.3	499	872
1981[a]	277	12.0	279	806
1982[a]	320	8.8	543	685
1983[b]	336	4.9	254	418
1984[b]	332	2.8	98	135
1985[b]	363	2.0	191	87
1986[a,b]	335	3.9	226	300
	Station 62032			
1976	139	2.5	116	91
1977	225	3.3	129	176
1978	281	2.5	134	141
1979	306	2.9	140	178
1980	307	3.3	124	210
1981	271	3.1	211	202
1982	269	2.1	99	115
1983	309	2.8	87	180
1984	314	1.9	74	38
1985	363	1.1	61	28
1986	325	1.2	133	37
	Station 62051			
1983	349	4.3	161	345
1984	366	5.3	284	509
1985	315	3.6	166	218
1986[d]	62	1.1	54	7

[a]Station 62030, [b]Station 62052, [c]Station 62030 and 62052.
[d]Station terminated March 4, 1986.

TABLE 11. Average annual dustfall (g/m²/30 d), Kenora, 1981-1986.

Station[a]	Location	1981	1982	1983	1984	1985	1986
61003	Fourth/Main	4.7[b]	3.1	2.5	4.8	5.4	3.3
61007	Melick/Ninth	14.1	10.0	7.0	10.9	9.7	8.9
61008	Melick/Eleventh	4.1	2.7	2.5	3.3	5.6	3.1
61009	Third/Matheson	7.1	4.5	3.3	4.5	5.1	3.2
	Averages	7.5	5.1	3.8	5.9	6.4	4.6

[a]See Figure 6.
[b]Values exceeding maximum acceptable level of 4.6 are underlined.

TABLE 12. Average annual sulphation rates (mg SO_3/100 cm²/d), Kenora, 1981-1986.

Station[a]	Location	1981	1982	1983	1984	1985	1986
61003	Fourth/Main	0.11	0.07	0.06	0.05	0.07	0.09
61007	Melick/Ninth	0.21	0.10	0.10	0.07	0.06	0.09
61008	Melick/Eleventh	0.18	0.15	0.20	0.11	0.09	0.08
61009	Third/Matheson	0.07	0.05	<0.05	<0.05	<0.05	<0.05
	Averages	0.14	0.09	0.10	0.06	0.06	0.07

[a]See Figure 6.

TABLE 13. Average annual dustfall levels (g/m²/30 d), Longlac, 1984-1986.

Station[a]	Location	Monthly range 1986	Annual average 1984	1985	1986
63070	Sewage Plant	2.1 - 6.5	5.8	5.0	3.8
63071	Centennial Drive	2.4 - 10.3[b]	7.7	6.9	6.4
63072	Poplar Street	1.6 - 11.1	6.3	4.2	4.5
63073	Dieppe Road	0.8 - 6.5	4.2	3.0	3.5
63074	Riverview Street	1.0 - 9.9	4.3	3.9	4.9
	Averages		5.7	4.6	4.6

[a]See Figure 7.
[b]Averages exceeding the objectives of 7.0 (monthly) or 4.6 (annual) are underlined.

TABLE 14. Average annual sulphation rates (mg SO_3/100 cm^2/d), Marathon, 1978 to 1986.

Station	Location	1978	1980	1982	1984	1986
63027	McLeod/Abrams	0.37	0.12	0.18	0.16	0.18
63029	Marathon Shell	0.20	0.09	0.11	b	0.08
63030	Howe/Yawkey	0.23	0.11	0.11	0.10	0.07
63032	Heron Bay	0.10	0.06	0.08	0.04	<0.05
63033	Water Tower	a	0.16	0.15	0.14	0.19
	Averages		0.12	0.13		0.11

[a]No monitoring.
[b]Insufficient data to calculate average.

TABLE 15. Summary of TRS concentrations (ppb) at station 63034, Marathon, 1983-86.

Year	Days of data	Annual average	Maximum 1-hour average	Number of hours above guideline
1983	310	0.9	72	25
1984	329	1.0	71	22
1985	343	1.3	83	52
1986	316	2.1	131	115

TABLE 16. Mercury (µg/g, dry weight) in soil sampled between 1976 and 1986 on James River-Marathon Limited property.

Site[a]	Soil Depth														
	0-5 cm					5-10 cm					10-15 cm				
	1976	1978	1980	1982	1986	1976	1978	1980	1982	1986	1976	1978	1980	1982	1986
2	4	5	3	4	3	3	2	3	5	2	3		2	4	0.5
6	14	18	4	28	21	11	2	0.3	22	6	6	4	0.4	10	0.6
8	3	5	4	15	7	5	0.8	8	13	1	0.8		7	3	0.5
9	36	58	45	55	89	32	13	10	44	80	21	3	2	30	2
14	18	12	5	10	4	14	4	1	13	4	13	2	<1	5	0.5
16	3	3	3	10	7	2	0.4	0.8	3	4	0.4	0.1	0.8	0.5	1
25	2	2	2	2	2	1	0.5	0.6	0.9	0.2	0.6	0.2	0.5	0.4	<0.1
27	1	1	3	4	3	0.9	0.4	2	2	0.6	0.5	0.4	0.4	0.4	0.2
32	48	43	21	49	1[c]	22	16	4	48	0.6[c]	6	4	2	39	0.8[c]
33	12	7	15	77				2	12				0.9	2	
Controls	<0.1	<0.1	<0.1	0.2	0.1	<0.1	<0.1	<0.1	0.2	0.03	<0.1	<0.1	<0.1	<0.1	<0.03

[a] See Figure 9(a).

[b] Values exceeding contaminant guideline (0.2 µg/g) are underlined.

[c] Site has been significantly disturbed since previous survey.

TABLE 17. Average annual dustfall (g/m²/30 d), Red Rock, 1980-1986.

Station[a]	1980-82		1983		1984		1985		1986	
	Total	Salt-cake	Total	Salt-cake	Total	Salt-cake	Total	Salt-cake	Total	Salt-cake
63080	9.2	2.0	5.9	0.9	9.0	0.9	6.8	1.3	5.9	0.8
63081	5.6	1.1	4.3	0.4	5.9	0.5	4.5	0.7	4.4	0.6
63082	12.6	5.4	6.0	1.6	7.0	0.8	4.9	1.1	4.6	0.8
63083	3.1	0.8	2.0	0.2	2.1	0.2	3.0	0.4	2.6	0.4
Average	12.6	2.3	4.6	0.8	6.0	0.6	4.8	0.9	4.4	0.6

[a]See Figure 10.

[b]Values exceeding annual objective of 4.6 g/m²/30 d are underlined.

TABLE 18. Summary of TRS concentrations (ppb) at station 63084, Red Rock, 1982-86.

Year	Days of data	Annual average	Maximum 1-hour average	Number of hours above guideline
1982	292	5.0	339	317
1983	300	1.8	156	98
1984	365	1.3	111	23
1985	362	2.0	104	117
1986	317	1.9	80	87

TABLE 19. Average annual sulphation rates (mg/SO_3/100 cm^2/d), Terrace Bay, 1982-1986.

Station	Location	1982	1983	1984	1985	1986
63090	St. Martin School	0.15	0.14	0.08	0.12	0.10
63091	Ft. Garry Road	0.10	0.14	0.08	0.14	0.10
63092	Terrace Heights Dr.	0.10	0.07	0.06	0.08	0.06
63093	Mill Road	0.10	0.08	0.09	0.13	0.09
63094	Highway 17, #1	0.10	0.14	0.13	0.13	0.08
63095	Highway 17, #2	0.08	0.08	0.06	0.08	0.06
63096	Highway 17, #3	0.04	0.06	0.06	0.04	<0.05
	Averages	0.10	0.10	0.08	0.10	0.08

TABLE 20. Summary of TRS concentrations (ppb) at station 63090, Terrace Bay, 1982-86.

Year	Days of data	Annual average	Maximum 1-hour average	Number of hours above guideline
1982	155	0.6	50	7
1983	333	0.9	102	30
1984	331	1.2	104	38
1985	364	1.4	200	67
1986	350	1.5	155	72

TABLE 21. Total dustfall ($g/m^2/30$ d), Thunder Bay, 1986.

Station	Location	Monthly Min	Monthly Max	Annual average
63005	McKellar Hospital	1.3	5.0	2.8
63012	Dawson Court	0.8	5.3	2.3
63019	Main St. Pumping Station	0.8	<u>19.0</u>	3.9
63021	Mission Island	0.5	3.4	1.7
63022	St. Joseph's Hospital	0.9	5.6	2.7
63026	N. Cumberland Hydro	1.2	5.1	2.7
63040	435 James St. South	0.8	4.1	2.0
63046	Montreal Street	1.8	6.9	3.8
63047	Totem Trailer Court	1.7	6.1	4.3
63052	Thunder Bay Transit	1.0	<u>9.8</u>	3.4

[a]Values exceeding maximum acceptable levels of 7.0 (monthly) or 4.6 (annual average) are underlined.

TABLE 22. Total dustfall (g/m²/30 d) at Totem Trailer Court (station 63047), during winter months from 1981 to 1987.

Year	Nov	Dec	Jan	Feb	Mar	Mean
1981-82	10.1[a]	12.7	8.7	9.8	12.6	10.8
1982-83	17.5	15.1	16.6	16.0	9.8	15.0
1983-84	9.1	6.5	9.9	3.1	6.9	7.1
1984-85	8.8	6.4	3.4	5.2	8.9	6.5
1985-86	3.4	2.5	2.2	6.4	2.8	3.5
1986-87	5.6	1.7	2.1	2.7	2.6	2.9

[a]Values exceeding maximum acceptable level of 7.0 are underlined.

TABLE 23. Total suspended particulate matter (µg/m³), Thunder Bay, 1986.

Station	Number of samples	Annual geometric mean	Number of samples above 120 µg/m³	Maximum 24-hour value
63005	57	40	1	122
63012	58	30	nil	104
63022	53	33	nil	105
63040	56	31	nil	78
63046	57	44	1	131
63052	59	44	3	202

[a]Values exceeding the maximum acceptable limit of 120 µg/m³ (24-hour average) or 60 µg/m³ (annual geometric mean) are underlined.

TABLE 24. Summary of sulphur dioxide concentrations (ppm) in Thunder Bay, 1986.

Station	Location	Annual average	Maximum 1-hour average	Maximum 24-hour average
63022	St. Joseph's Hospital	<0.001	0.01	<0.01
63040	435 S. James Street	<0.001	0.15	0.02
63041[a]	Mt. McKay		0.15	0.04
63042[a]	East End		0.05	<0.01
63044[a]	James St./Kam River		0.08	0.02
63048[a]	Ford Street		0.04	0.01
63049[a]	Chippewa Park		0.07	0.01

[a]Ontario Hydro. 1986-87. Environmental Quality Compliance Reports, 1986. Technical and Training Services Division.

TABLE 25. Summary of total reduced sulphur concentrations (ppb), station 63046, Thunder Bay, 1977-1986.

Year	Days of data	Annual average	Maximum 1-hour average	Number of times above guideline
1977	298	1.5	56	17
1978	280	1.9	48	28
1979	218	2.6	58	26
1980	220	2.9	131	90
1981	340	2.8	72	74
1982	299	1.0	36	7
1983	305	0.5	36	3
1984	164	0.6	22	nil
1985	286	0.8	27	nil
1986	337	1.0	55	4

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